MARCH 1957

Journal

VOL. 49 • NO. 3

AMERICAN WATER WORKS ASSOCIATION

Beneath the Continental Divide: Roberts Tunnel through which Denver will tap the Colorado

In this issue:

FORECASTING WATER REQUIREMENTS
Wolff, Willis

FLOCCULATION AND FLOCCULATION AIDS
Hudson

WESTERN SLOPE DEVELOPMENT FOR DENVER
Mosley

FACILITIES FOR PEAK DEMAND STORAGE
Freese

EFFECTS OF SPRINKLING RESTRICTIONS
Heggie

WATER SUPPLY FROM UPLAND STORAGE
Williams

GROUND WATER IN SOUTH CAROLINA
Siple

AUTOMATION AND THE AUTOMATIC VALVE
End

PROBLEMS OF WATER FOR INDUSTRY
Haynes, Lewis

AQUATIC PLANTS IN RESERVOIRS
Cooke, Ingram, Bartsch, Enright

SUBURBAN WATER SUPPLY AT CINCINNATI
Mace

VALUE OF SLUDGE CALCINING
Krause

ASSOCIATION ACTIVITIES IN 1956
Committee Reports

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Also available with stem coupling and breakable flange

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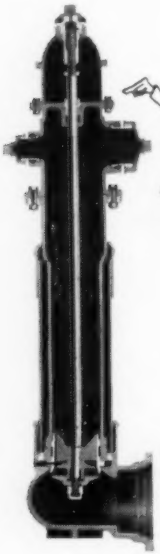

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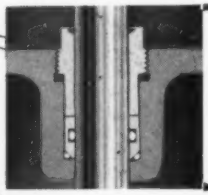

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Journal

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March 1957

Vol. 49 • No. 3

Contents

Forecasting Water Requirements for Distribution Systems
- Forecasting Residential Requirements.....JEROME B. WOLFF 225
- Forecasting Industrial Requirements.....M. JOSEPH WILLIS 235

Flocculation and Flocculation Aids.....HERBERT E. HUDSON JR. 242
Western Slope Water Development in Denver.....EARL L. MOSLEY 251
Peak Demand Storage.....SIMON W. FREESE 263
Effects of Sprinkling Restrictions.....GLEN D. HEGGIE 267
Correction—Liquid Alum at Milwaukee (JAMES E. KERSLAKE)..... 276
Water Supply From Upland Storage.....LEON G. WILLIAMS 277
Reprints Available..... 282
Ground Water in the South Carolina Coastal Plain.....GEORGE E. SIPLE 283
Automation and the Automatic Valve.....WILLIAM F. END JR. 301
Treatment of Industrial Water Pollution at Nitro and Charleston, W.Va. LAWSON HAYNES 309
Steel Pipe Joint Standards Revised..... 312
Water Supply for Large Industries.....ROBERT C. LEWIS 313
Submerged Aquatic Plants in a Primary Settling Reservoir WILLIAM BRIDGE COOKE, WILLIAM MARCUS INGRAM, ALFRED F. BARTSCH & J. DANIEL ENRIGHT 318
A Water Supply for Suburban Cincinnati.....HAROLD H. MACE 322
Value of Sludge Calcining.....FRED KRAUSE 327
Report of the Committee on Water Works Administration..... 331
AWWA Safety Awards Plan..... 339
Report of the Committee on Water Works Practice..... 341
Report on Publications..... 349
Report of the Audit of Association Funds..... 361
Section Membership Awards and Statistics..... 367

Departments

Officers and Directors	*2 P&R*	Employment Information	*76 P&R*
Coming Meetings	*6 P&R*	Reading Meter	*88 P&R*
Percolation and Runoff	*41, 78 P&R*	Service Lines	*94 P&R*
Conference Program	*52 P&R*	New Members	*98 P&R*
Condensation	*64 P&R*	Index of Advertisers' Products	*104 P&R*

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LIST OF ADVERTISERS

	PAGE
Ace Pipe Cleaning, Inc.	—
AG Chemical Co.	—
Alabama Pipe Co.	84
Alco Products, Inc.	—
Allis-Chalmers	63
American Agricultural Chemical Co.	46
American Brass Co., The	—
American Cast Iron Pipe Co.	34
American Concrete Pressure Pipe Assn.	29
American Cyanamid Co., Heavy Chemicals Dept.	82, 83
American Pipe & Construction Co.	91
American Well Works	—
Anthracite Equipment Corp.	—
Armco Drainage & Metal Products, Inc.	97
Badger Meter Mfg. Co.	16, 17
Barrett Div.	—
Bethlehem Steel Co.	—
B-I-F Industries, Inc.	5, 45
Buffalo Meter Co.	—
Builders-Providence, Inc. (Div., B-I-F Industries)	5
Byron Jackson Div., Borg-Warner Corp.	—
Calgon, Inc.	—
Carborundum Co., The	—
Carson, H. Y., Co.	100
Carus Chemical Co.	—
Cast Iron Pipe Research Assn., The	70, 71
Catskill Craftsmen, Inc.	—
Centriline Corp.	19
Chain Belt Co.	56
Chapman Valve Mfg. Co.	81
Chicago Bridge & Iron Co.	26
Clow, James B., & Sons	9, 47
Cochrane Corp.	33
Cole, R. D., Mfg. Co.	104
Crane Co.	99
Darley, W. S., & Co.	100
Darling Valve & Mfg. Co.	103
De Laval Steam Turbine Co.	93
DeZurik Corp.	14
Dicalite Div.	—
Dorr-Oliver Inc.	Cover 3
Dresser Mfg. Div.	105
du Pont, I. E., de Nemours & Co.	—
Eddy Valve Co.	9, 47
Electro Rust-Proofing Corp.	—
Electrovert Ltd.	—
Ellis & Ford Mfg. Co.	—
Everson Mfg. Corp.	—
Filtration Equipment	76
Fischer & Porter Co.	—
Flexible Inc.	25
Ford Meter Box Co., The	32
Foster Engineering Co.	96
Foxboro Co.	—
Frontier Chemical Co.	—
General Chemical Div., Allied Chemical & Dye Corp.	—
General Filter Co.	27
Golden-Anderson Valve Specialty Co.	—
Graver Water Conditioning Co.	—
Greenberg's, M., Sons	89
Hammond Iron Works	—
Harco Corp.	—
Hays Mfg. Co.	15
Hersey Mfg. Co.	37
Hungerford & Terry, Inc.	48
Hydraulic Development Corp.	—
Industrial Chemical Sales Div., West Virginia Pulp & Paper Co.	39
Inertol Co., Inc.	101
Infilco Inc.	43
International Salt Co.	10, 11
Iowa Valve Co.	9, 47
Johns-Manville Corp.	35
Jones, John Wiley, Co.	74
Keasbey & Mattison Co.	111
Kennedy Valve Mfg. Co., The	—
Klett Mfg. Co.	92
Koppers Co., Inc	66, 67
LaMotte Chemical Products Co.	—
Layne & Bowler, Inc.	36
Leadite Co., The	Cover 4
Leopold, F. B., Co.	107
Lock Joint Pipe Co.	3
Ludlow Valve Mfg. Co.	30
M & H Valve & Fittings Co.	28
Millipore Filter Corp.	50, 51
Milton Roy Co.	79
Minneapolis-Honeywell Regulator Co.	55
Monolith Portland Midwest Co.	—
Mueller Co.	facing p. 64
National Cast Iron Pipe	9, 47
National Water Main Cleaning Co.	31
Neptune Meter Co.	40
Northern Gravel Co.	7
Omega Machine Co. (Div., B-I-F Industries)	—
Permutit Co.	12, 13
Phelps Dodge Refining Corp.	—
Philadelphia Quartz Co.	—
Pittsburgh-Des Moines Steel Co.	—
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.)	112
Pollard, Jos. G., Co., Inc.	20
Portland Cement Assn.	—
Pratt, Henry, Co.	24
Proportioneers, Inc. (Div., B-I-F Industries)	45
Reed Mfg. Co.,	—
Reilly Tar & Chemical Corp.	—
Rensselaer Valve Co.	30
Roberts Filter Mfg. Co.	109
Rockwell Mfg. Co.	112
Rockwell, W. S., Co.	85
Ross Valve Mfg. Co.	53
Schleicher, Carl, & Schuell	—
Servicised Products Corp.	—
Simplex Valve & Meter Co.	21
Smith, A. P., Mfg. Co., The	77
Smith, S. Morgan, Co.	87
Smith-Blair, Inc.	—
Sparling Meter Co.	—
Sparton Control Systems	—
Spring Load Mfg. Corp.	—
Stearns-Roger Mfg. Co.	—
Steel Plate Fabricators Assn.	73
Stuart Corp.	—
Tennessee Corp.	18
Trinity Valley Iron & Steel Co.	—
U.S. Pipe & Foundry Co.	22, 23
Wachs, E. H., Co.	—
Walker Process Equipment, Inc.	75
Wallace & Tiernan Inc.	38
Well Machinery & Supply Co.	69
Western Materials Co.	—
Wheeler, C. H., Mfg. Co.	95
Wood, R. D., Co.	Cover 2
Woodward Iron Co.	—
Worthington Corp.	—
Worthington-Gamon Meter Div	49

Directory of Professional Services—pp. *57-62 P&R*

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AWWA ANNUAL CONFERENCE

Atlantic City, N.J. May 12-17, 1957

Official reservation forms have been mailed to all members and are returnable to AWWA. (See preliminary program on pp. 52–54 P&R.)

Coming Meetings

AWWA SECTIONS

Winter-Spring Meetings

Mar. 17–20—Southeastern Section, at Francis Marion Hotel, Charleston, S.C. Secretary, N. M. deJarnette, Engr., Div. of Water Pollution Control, State Dept. of Public Health, 245 State Office Bldg., Atlanta 3, Ga.

Mar. 20–22—Illinois Section, at LaSalle Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

Apr. 4–6—Arizona Section, at Maricopa Inn, Mesa. Secretary, H. C. Bigglestone, Luhrs Tower, Phoenix.

Apr. 5–6—Montana Section, at Rainbow Hotel, Great Falls. Secretary, Arthur W. Clarkson, Acting Chief, Water Sec., Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 10–12—Kansas Section, at Broadview Hotel, Wichita. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 10–12—New York Section, at Mark Twain Hotel, Elmira. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Apr. 24–26—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, John E. Olsson, 408 Sharp Bldg., Lincoln.

Apr. 27—California Section, at Miramar Hotel, Santa Monica. Secretary, H. J. Ongerth, 2151 Berkeley Way, Berkeley.

May 2–4—Pacific Northwest Section, at Winthrop Hotel, Tacoma, Wash. Secretary, Fred D. Jones, Asst. Supt., Water Dept., Rm. 306, City Hall, Spokane, Wash.

Jun. 6—New Jersey Section Spring Outing & Luncheon, at Canoe Brook Country Club. Secretary, Albert F. Pleibel, Dist. Sales Manager, R. D. Wood Co., 683 Prospect St., Maplewood.

(Continued on page 8)

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FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

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Coming Meetings

(Continued from page 6)

Jun. 12–14—Pennsylvania Section, at Bedford Springs Hotel, Bedford Springs. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Jun. 17–19—Canadian Section, at Royal Alexandra Hotel, Winnipeg, Man. Secretary, A. E. Berry, Director, San. Eng. Div., Ontario Dept. of Health, 72 Grenville St., Toronto, Ont.

Fall Meetings

Sep. 4–6—Wisconsin Sec., Milwaukee.

Sep. 11–13—New York Sec., Lake Placid.

Sep. 18–20—Ohio Sec., Cincinnati.

Sep. 23–25—Kentucky-Tennessee Sec., Louisville, Ky.

Sep. 25–27—Michigan Sec., Detroit.

Sep. 25–27—North Central Sec., Fargo, N.D.

Sep. 29–Oct. 1—Missouri Sec., St. Louis.

Oct. 13–16—Southwest Sec., Oklahoma City, Okla.

Oct. 16–18—Iowa Sec., Des Moines.

Oct. 20–23—Alabama-Mississippi Sec., Biloxi, Miss.

Oct. 23–24—West Virginia Sec., Wheeling.

Oct. 24–26—New Jersey Sec., Atlantic City.

Oct. 30–Nov. 1—Chesapeake Sec., Washington, D.C.

Oct. 29–Nov. 1—California Sec., San Jose.

Nov. 6–8—Virginia Sec., Roanoke.

Nov. 11–13—North Carolina Sec., Raleigh.

OTHER ORGANIZATIONS

Mar. 19–21—American Meteorological Society, at Univ. of Chicago, Chicago, Ill.

Mar. 25–29—Western Metals Congress & Exhibition, at Ambassador Hotel and Pan-Pacific Auditorium, Los Angeles, Calif. Managing Director, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

Mar. 25–29—Public Utilities Safety Course, sponsored by National Safety Council, at Chicago, Ill. Write: G. F. Griffin, Director of Industrial Training, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

Apr. 2–4—Corrosion Control Short Course, at Extension Study Center, Univ. of Oklahoma, Norman, Okla.

Apr. 8–12—American Welding Society, at Hotel Sheraton, Philadelphia, Pa.

May 13–15—Industrial Waste Conference, Purdue Memorial Union Bldg., Purdue Univ., Lafayette, Ind.

May 20–22—Northeast Region Spring Conference (NACE) on Corrosion Control by Choice of Materials, Syracuse, N.Y. Write: O. R. Broberg, Lamson Corp., Syracuse, N.Y.

Jun. 2–6—Municipal Finance Officers Assn., at Hotel Lowry, St. Paul, Minn.

Jun. 16–21—American Society for Testing Materials, Atlantic City, N.J.

Aug. 5–9—Gordon Research Conference on Ion Exchange, at Kimball Union Academy, Meriden, N.H. Write: W. G. Parks, Director, Dept. of Chemistry, Univ. of Rhode Island, Kingston, R.I.

Oct. 7–10—Federation of Sewage & Industrial Wastes Assns., at Statler Hotel, Boston, Mass.

Nov. 2–8—World Metallurgical Congress, sponsored by American Society for Metals, at Chicago, Ill.

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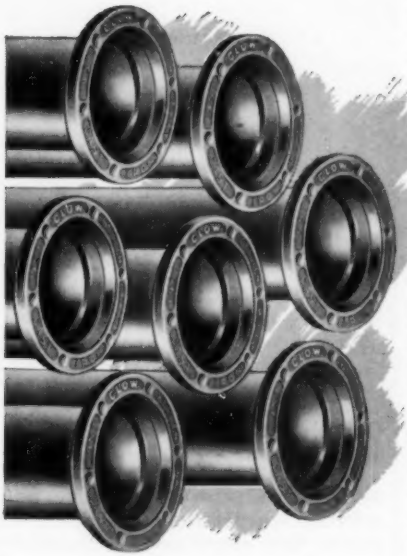

Experienced men who specify and install underground water pipe take advantage of the plus factors when they specify cast iron pipe.

Take the pressure plus factor. Minimum wall thickness Clow cast iron pipe (ASA A21.6 Class 22) is rated for at least 250 psi working pressure in diameters 10″ and smaller.

What does this mean? It means that cast iron pipe is rated safely above the minimum pressure requirements for municipal water service, and can be specified to the full ASA rated working pressure. This is because of the inherent strength of cast iron pipe . . . beam strength . . . compressive strength . . . bursting strength . . . all scientifically calculated with ample factor of safety on the basis of sound engineering practice and the result of actual service records.

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How Soon Will Your Community Have Soft Water?

With today's trend to soft water has come a significant increase in the number of municipal water-softening installations. And predictions are that more and more treatment plants will add softening equipment during 1957 and 1958. As a service to the towns and cities planning these installations, International Salt Company has prepared a series of articles on water-softener regeneration. Number 1 . . .

Regeneration of softeners using base-exchange zeolites and/or resins is accomplished most efficiently and economically with "Lixate Brine"

Today, Lixate Brine is used in a wide variety of industrial and municipal applications for water-softener regeneration. This high-quality brine is produced by the Lixate Process—an exclusive development of the International Salt Co. Here are some details on this famous brine-making process, showing how it can benefit your treatment plant.

The Sterling Lixator is the heart of the Lixate Process. A simple, automatic rock-salt dissolver, the Lixator reduces costs of regeneration . . . eliminates salt handling . . . and makes possible other important savings. This is because the Lixator *combines* dissolving and brine filtration in one operation; and because fully saturated, crystal-clear Lixate Brine can be delivered automatically from the Lixator to any point in the plant.

The Lixator is remarkably easy to maintain

. . . has no moving parts to get out of order. In operation, the Lixator need not replace the salt-dissolving tanks furnished by water-softener manufacturers. Instead Lixate Brine is piped to these tanks—which then serve as storage and measuring tanks from which the brine can be withdrawn for use.

Salt handling reduced

Because Lixate Brine is piped to points of use, the work of hauling dry salt from storage piles to the location of the water softeners is eliminated. Also, because of this direct-piping feature, the Lixator (and the salt that feeds it) can be placed anywhere in the plant, to make the most efficient use of available space.

Complete regeneration

Since Lixate Brine is always 100% saturated, it provides complete water-softener regeneration each time. This means that extra regenerations—with the consequent use of more salt—are eliminated. In addition, operators will not use any more of this brine than is needed for each regeneration. What often happens in the case of brine less than 100° S, is that excess amounts are used in an attempt at complete regeneration.

Keeps water softeners clean

Lixate Brine—produced from economical grades of Sterling Rock Salt—is self-filtered, and free from insolubles or other foreign matter. As a result, it will not introduce dirt or other "clogging material" into the bed of the water softener. Lixate Brine is also free from acids or alkalies. Being neutral, it cannot affect the performance of any water-softening system.

International makes available its full range of technical and engineering service on regeneration of base-exchange zeolites and/or resins

For example, through skilled and experienced "Salt Specialists," International can give you helpful information on modern regeneration techniques. This information has been developed as a result of International's extensive work on water softening in the chemical, textile, food-processing, and meat-packing industries.

In addition, the "Salt Specialists" will work with you or your consulting engineers in selecting the right type and size of salt for your regeneration needs . . . in finding effective salt-storage and salt-handling methods . . . in planning a Lixator installation . . . and in determining the best means for distributing brine—to mention just a few of their services.

One feature of this advisory service which is of special importance is its complete *impartiality*. Because International produces all types and sizes of salt, we have no reason to recommend one salt product over another. We simply recommend the best possible type and size of salt for your water-softening needs.

Here's the unit that produces 100° S. brine, automatically . . . a Sterling Model Lixator in corrosion-proof plastic. Lixators are widely used for water-softener regeneration in municipal plants, canning, meat packing, chemical manufacture, etc. Lixator is about 8 feet high, takes little floor space. Other Lixator models are available in steel, or Monel metal; and can be made for different brine capacities.

To get this free technical assistance

. . . simply contact your nearest International Sales Office. There's one in your area. *Sales Offices:* Atlanta, Ga.; Chicago, Ill.; New Orleans, La.; Baltimore, Md.; Boston, Mass.; Detroit, Mich.; St. Louis, Mo.; Newark, N.J.; Buffalo, N.Y.; New York, N.Y.; Cincinnati, O.; Cleveland, O.; Philadelphia, Pa.; Pittsburgh, Pa.; and Richmond, Va.

INTERNATIONAL SALT CO., INC.

SCRANTON, PA.

HOW TO SELECT WATER-CONDITIONING EQUIPMENT

(NO. 1 OF A SERIES)

Aerators, Degasifiers, Deaerators

If you want to remove dissolved gases or iron or taste and odor from large quantities of water, you will probably use aeration or degasification as part of the treatment.

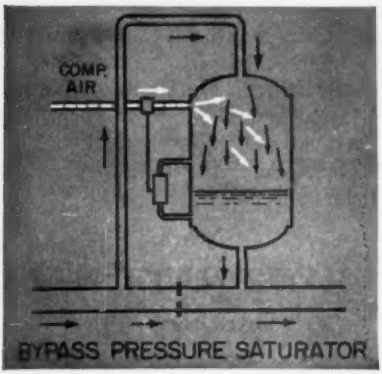
Modern equipment for putting air or gases into water or taking them out is highly specialized, ranging from simple, low cost aerators to complex, highly efficient degasifiers.

The following descriptions may help you choose the type of equipment that best solves your problem at the lowest cost.

To introduce air. If your problem is simple introduction of air to oxidize iron or manganese, **pressure aeration** may be preferred to avoid repumping. But introducing air into water under pressure can result in supersaturation when the pressure is reduced, causing "milky water" and filter troubles from air binding or upset beds.

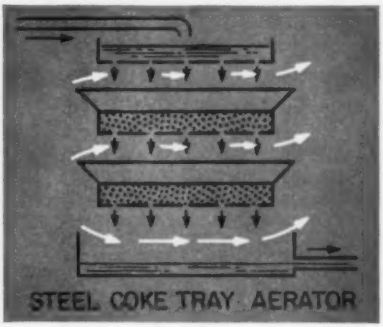
A Bypass Pressure Saturator automatically provides aeration without the danger of supersaturation by introducing air to only a predetermined portion of the total flow. (Patented by Permutit.)

If you want to reduce CO_2 or taste and odor or accomplish any of these at the same time that you oxidize iron or manganese, an **aerator** is recommended.



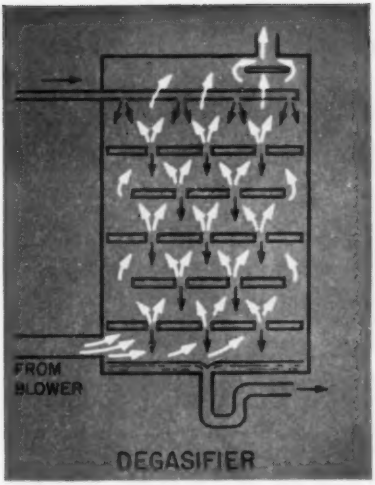
BYPASS PRESSURE SATURATOR

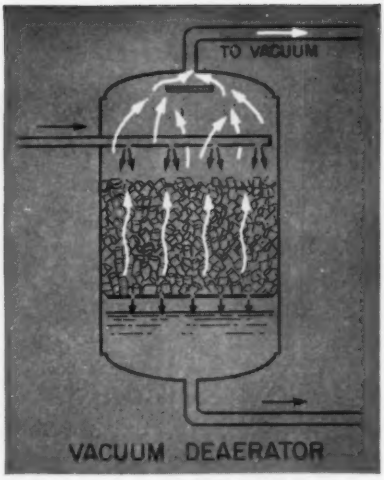
Aerators may be of the open type in which water cascades over trays of graded coke or a series of wood slat trays. Splash aprons reduce splashing, permit free circulation of air. Formation of iron or manganese film on coke surfaces hastens oxidation reactions. Some reduction of CO_2 may also take place, raising pH and further helping oxidation.


STEEL COKE TRAY AERATOR

To remove dissolved gases. For practically complete removal of CO_2, methane, hydrogen sulfide or other gases, the most efficient way is by a **degasifier.**

In a degasifier, water rains down through Raschig rings or wood slat packing countercurrent to a large flow of air from a blower.





Thus the freshest air contacts the effluent water, gives lower final gas content. Proper packing design breaks water into thin films, promotes rapid and efficient gas removal.

Degasifiers are totally enclosed, avoiding splashing and spray losses. Outer tank may be of wood, rubber-lined steel, stainless steel or aluminum. Cylindrical units are usually more economical, but square or rectangular shapes may be used. Sizes and capacities are practically unlimited, depending on requirements. Units can be used for water with CO_2 as high as 3500 ppm.

Although degasifiers provide very complete aeration, their higher cost is unwarranted in many cases where simple introduction of air is the main objective.

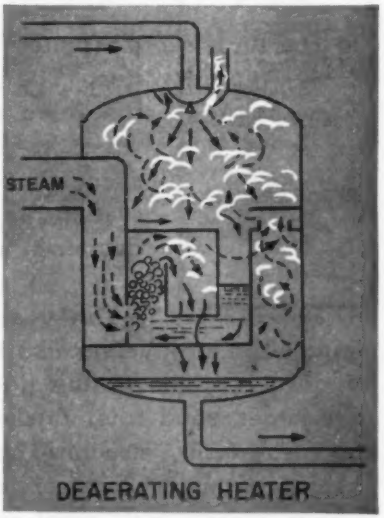
To remove oxygen. If you want to remove oxygen without heating the water, use **vacuum deaeration.**

A vacuum deaerator is a steel tank lined where necessary and containing suitable packing such as Raschig rings. A vacuum is maintained in the tank by steam jet ejectors or motor-driven vacuum pumps. Under a vacuum, solubility of gases in water is greatly lowered. As the water trickles down through the packing, the gases present, including oxygen, nitrogen and carbon dioxide, are liberated and drawn off. Type and depth of packing, degree of vacuum, flow rates and other variables must be accurately adapted to your specific conditions for best efficiency.

If the water is to be heated as for feeding boilers, a vacuum is not necessary, and a **deaerating heater** is recommended.

In a spray type deaerating heater, the water is first sprayed through steam which removes most of the non-condensable gases. (The gas-laden steam is condensed and vented.) The water is then reboiled by passing steam through it for final deaeration.

Where less complete removal of oxygen is required, the reboiling (scrubbing) stage may be omitted.

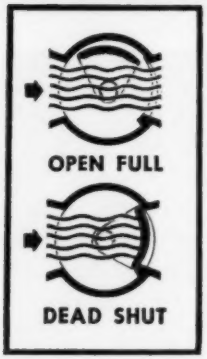


For detailed information on these or any other types of water-conditioning equipment, write: The Permutit Company, Dept. JA-3, 330 West 42nd St., New York 36, N.Y. or Permutit Company of Canada, Ltd., Toronto 1, Ont.

PERMUTIT® *rhymes with "compute it"*

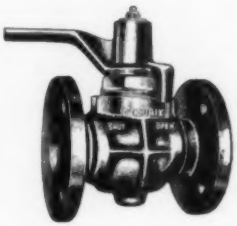
Water Conditioning • Ion Exchange
Industrial Waste Treatment

NO LUBRICATION... NO FRICTION... NO LEAKAGE WITH EASY OPERATING DeZURIK PLUG VALVES



DeZurik's *exclusive* eccentric principle *guarantees* easy operation without lubrication. The plug is pivoted eccentrically in the valve and touches the valve seat *only* when the valve is closed. Opening the valve swings the plug back away from the valve seat and the valve opens wide with an easy quarter turn.

The resilient plug-facing of DeZurik Valves assures tight shut-off despite solids in the flow. On raw water inlet, sand filter intake (discharge and backwash), structure drainage discharge and many other services, DeZurik Valves perform with equal excellence.

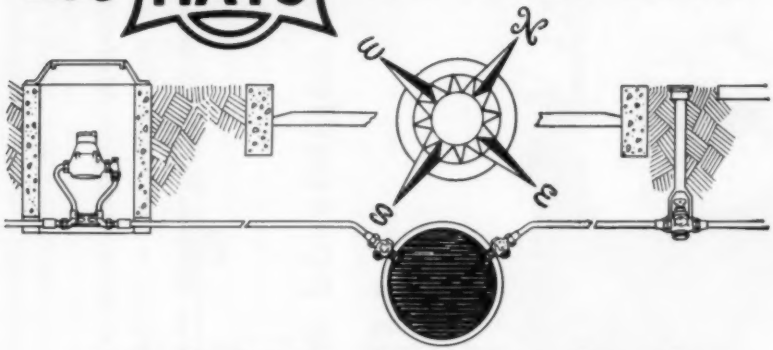


DeZurik Valves are available in sizes from ½" thru 20", for manual or remote operation. Representatives in all principal cities. For details, write to

DeZURIK CORPORATION
SARTELL, MINNESOTA.

Wherever You Are...

use HAYS WATER SERVICE PRODUCTS



at Both Ends of the Service Line

For underground installations, only the *highest quality* should be considered . . . that's why Water Departments all over the country have been using HAYS Water Service Products for over 80 years.

HAYS makes a complete line of Corporation and Curb Stops conforming to all A.W.W.A. Standards, also a line of Curb Boxes.

HAYS also makes a line of Copper Meter Setters and Meter Raisers, along with stops and fittings required in connection with meter installations.

The HAYS Model B Tapping Machine, with aluminum alloy body, is 1/3 lighter, easier to carry, easier and faster to operate, gives more working room . . . really designed for "the man in the ditch."

Write for literature or ask "The Man from Hays."

COPPER METER SETTERS

MODEL "B" TAPPING MACHINE

CORPORATION STOP

ROUNDWAY CURB STOP

Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.

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WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.
ERIE, PA.

Forests Protected . . .

but how about our most precious possession . . . water?

You'll save water—increase the system income—with Badger Meters

Forest conservation costs millions — and it's worth it. But the millions of *wasted gallons* of increasingly scarce water *could* cost the future of entire communities. Yet one basic step—replacing flat rates with Badger Meters — sharply reduces waste. Water revenue rises. And because they are Badger Meters, peak meter performance is assured for years.

— sharply reduces waste. Water revenue rises. And because they are Badger Meters, peak meter performance is assured for years.

Badger Meters have an unsurpassed record for low maintenance cost: ruggedly built of finest copper alloy. Control adjustment is simple. Working parts are few and standardized for easy, inexpensive replacement if ever needed.

By thus installing the finest meters available—Badger Meters—you put the department on an efficient, good-business basis, while saving vital water supplies through fair-share, fair-pay metering. Act now! Write for literature or to arrange a helpful consultation with a Badger Meter representative.

Outstanding disc, turbine and compound meters—⅝" through 12" —precision-engineered for lasting service.

Water is vital

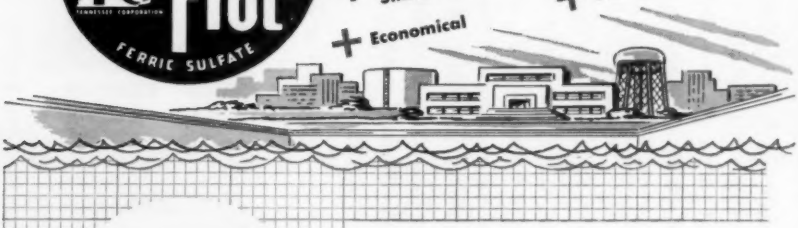
Badger Meters have conserved it better for over 50 years.

Badger Water Meters

BADGER METER MFG. CO. — 2371 North 30th Street
Milwaukee 45, Wisconsin • *OFFICES IN PRINCIPAL CITIES*

Ferri-Floc
FERRIC SULFATE

+ Excellent Taste and Odor Control
+ Rapid Floc Formation
+ Bacteria Removal
+ Manganese and Silical Removal
+ Economical
+ Coagulation Over Wide pH Range
+ Color Removal
+ Turbidity Removal
+ Ease of Operation
+ Increased Filter Runs



The Superior
COAGULANT
With the Plus
FACTORS—

Ferri-Floc gives smoother, more efficient and trouble free operation. Whatever your particular water treatment problem may be, you can depend on Ferri-Floc doing a superior job and doing it efficiently and economically—Ferri-Floc is a free flowing granular salt which can be fed with few modifications through any standard dry feed equipment. It is only mildly hygroscopic, thereby permitting easy handling as well as storage in closed hoppers over long periods of time.

WATER TREATMENT

Efficient coagulation of surface or well waters. Aids taste and odor control—Effective in lime soda-ash softening. Adaptable to treatment of nearly all industrial waters.

SEWAGE TREATMENT

Ferri-Floc coagulates water and wastes over wide Ph ranges—it provides efficient operation regardless of rapid variations of raw sewage and is effective conditioning sludge prior to vacuum filtration or drying on sand beds.

LIQUID

SULFUR DIOXIDE

SULFUR DIOXIDE is effectively used for dechlorination in water treatment and to remove objectionable odors remaining after purification.

COPPER SULFATE

COPPER SULFATE will control about 90% of the microorganisms normally encountered in water treatment more economically than any other chemical.

FREE BOOKLET

Let us send you without charge, a 38 page booklet that deals specifically with all phases of coagulation — just send us a postal card.

TENNESSEE CORPORATION

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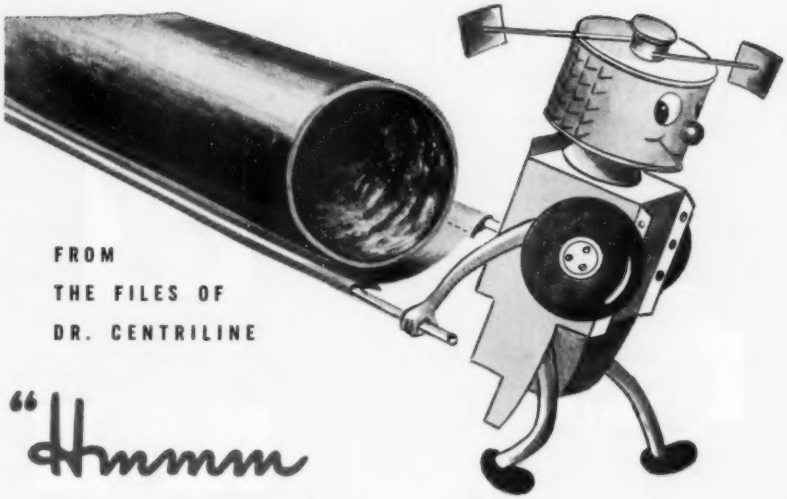

FROM
THE FILES OF
DR. CENTRILINE

"Hmmm ...a bad case of corrosion"

CASE #7841

PATIENT:	8 Miles of 16" and 12" Cast Iron Water Supply Lines in Abington-Rockland (Mass.) Water District.
SYMPTOMS:	Lack of water and pressure during periods of high demand requiring restrictions in the summertime.
DIAGNOSIS:	Poor circulation due to regrowth of tuberculation after cleaning. Available water could not be delivered to consumers.
TREATMENT:	The lines were cleaned and cement lined in place without interrupting service to consumers. In less than 8 weeks the entire job was completed.
RESULTS:	Patient now sound and healthy; pipe capacity permanently doubled, no further summer restrictions, future maintenance costs were eliminated.

If your lines also show signs of suffering from corrosion, leakage or tuberculation, investigate the Centriline Process. Cleaning and cement lining in place has been a successful remedy for over 1,000 miles of water supply pipelines. Centriline hasn't lost a patient yet.

CENTRILINE CORPORATION

A subsidiary of the Raymond Concrete Pile Company

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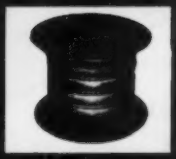
THE NATION'S No. 1 SOURCE

for dependable pipe line equipment

Like hundreds of Pollard customers, you'll find it mighty pleasant and convenient to order pipe line equipment from Pollard.

Here, under one roof and listed in one comprehensive catalog, are all the time and money saving products you need on the job. Each is guaranteed for dependability, economy. Each is backed by Pollard service.



MANHOLE CUSHION

DIAPHRAGM PUMPS

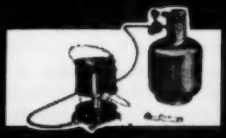
JOINT RUNNER

PIPE CUTTERS

MAKE POLLARD YOUR SOURCE FOR PIPE LINE EQUIPMENT. ORDER FROM POLLARD CATALOG 26.

M'SCOPE PIPE FINDER

CALKING TOOLS



MELTING FURNACE

PIPE LINE EQUIPMENT

JOSEPH G. POLLARD CO., INC.

PIPE LINE EQUIPMENT

PIPE LINE EQUIPMENT

Place your next order with POLLARD

If It's from POLLARD . . . It's the Best in Pipe Line Equipment

NEW HYDE PARK • NEW YORK

Branch Offices: 1064 Peoples Gas Building, Chicago, Illinois
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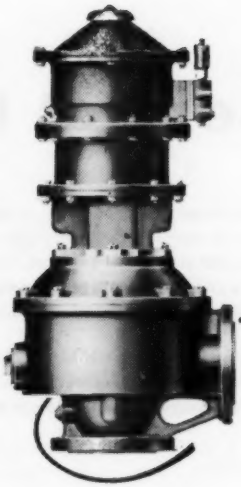

New Simplex Type CCAV Valve. Combination controlled-closing and vacuum-breaking valve.

ONE 4-INCH CONNECTION to your main pipe line...

PREVENTS *surge rupture vacuum collapse*

Why take chances? No matter what the safety factor, surge and hammer can play some dirty tricks . . . rupture lines, blow out packing, fracture valves. And if the line breaks or is drained rapidly, it can collapse from vacuum.

Simplex Type CCAV is a new combination! A controlled-closing and vacuum-breaking valve to protect your lines against both of these dangers. It's easily installed, moderately priced, positive-acting.

When lines are being filled, Type CCAV Valve vents air to prevent binding, controls transfer time to prevent surge damage. Timing can be quickly set from a few seconds up to well over ten minutes—as dictated by site requirements. If hammer is excessive, Type CCAV automatically discharges water . . . extra protection for costly lines and fittings.

When lines are subject to collapse from rapid draining or line breaks, the Simplex CCAV acts quickly . . . breaks the vacuum for maximum safety.

WRITE FOR FREE BROCHURE

SIMPLEX VALVE & METER COMPANY
DEPT. JA-3, 7 E. ORANGE ST., LANCASTER, PA.

SIMPLEX®

VALVE AND METER COMPANY

a perfect fit!

The ingenious "Tyton Joint" is simple, speedy and
sure. A specially designed rubber gasket fits into
bell end of the receiving pipe. The connecting
pipe slides easily into place, compressing the gas
which provides a tight and lasting seal.

"Tyton Joint" is remarkably easy to install. No bell h
Can be laid in rain or wet trench. Even an
inexperienced crew masters the know-how quickl

"AH WARNED ONCLE RAFE NOT TO STICK
HIS HEAD IN, GRAN'MAW..."

U.S. cast iron PIPE

FOR WATER, SEWERAGE A

et the facts on this new joint that saves
me, trouble, money in the trench.

ll or write today.

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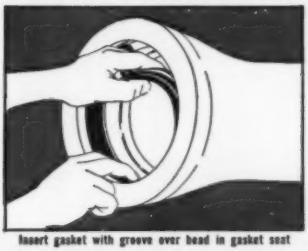
WHOLLY INTEGRATED PRODUCER FROM MINES
ND BLAST FURNACES TO FINISHED PIPE

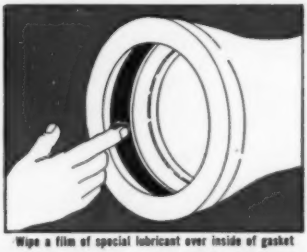
NDUSTRIAL SERVICE CAST IRON

TYTON JOINT

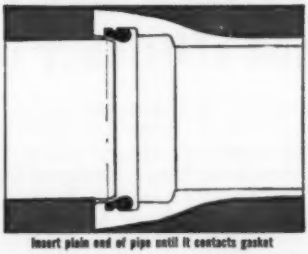
ONLY FOUR SIMPLE ACTIONS



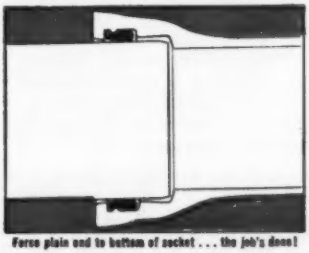
Insert gasket with groove over bead in gasket seat



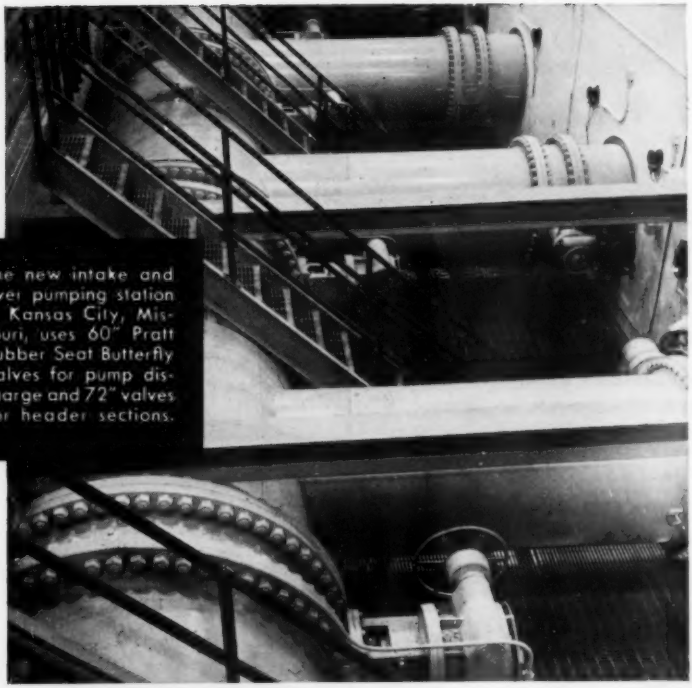
Wipe a film of special lubricant over inside of gasket



Insert plain end of pipe until it contacts gasket



Force plain end to bottom of socket . . . the job's done!



The new intake and river pumping station in Kansas City, Missouri, uses 60" Pratt Rubber Seat Butterfly Valves for pump discharge and 72" valves for header sections.

KANSAS CITY:
Rugged efficiency in a minimum space

Look! A modern pumping station with compact, unobtrusive large-diameter valves that require no more clearance than a standard pipe flange, and operators that are equally compact. Face-to-face dimensions of these 60" and 72" diameter Henry Pratt Rubber Seat Butterfly Valves are only 15" and 18" respectively.

Specifying Pratt valves means important savings in space and installation costs—but even more important, economy through years of efficient, maintenance-free operation.

Pratt originated the Rubber Seat Butterfly Valve and has installed more of them than any other manufacturer.

For valve design with a 50 year reputation for practical imagination, see Henry Pratt.

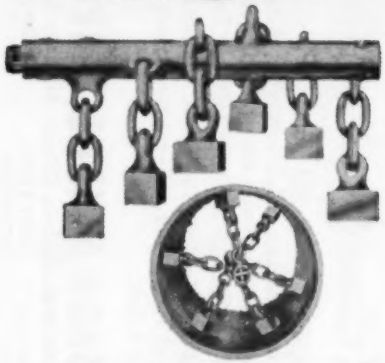
NEW! Latest, most accurate pressure drop and flow data, conversion tables, discussion of butterfly valve theory and application plus other technical information.
Write for Manual B-2C.

HENRY PRATT

RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

These EASY-TO-USE *Tools Cleaned* MILLIONS OF FEET OF "*Impossible*" JOBS!



The only "secret" for easily removing hard encrustations from water mains is *the right tool.* Water engineers throughout the world report that even inexperienced workmen, using the Chain Head Auger illustrated, can restore, to full capacity, pipe that would *otherwise need to be replaced.*

Centrifugal force, driving the hard-faced "chain heads" against the uneven pipe encrustations, provides fast, efficient cleaning action.

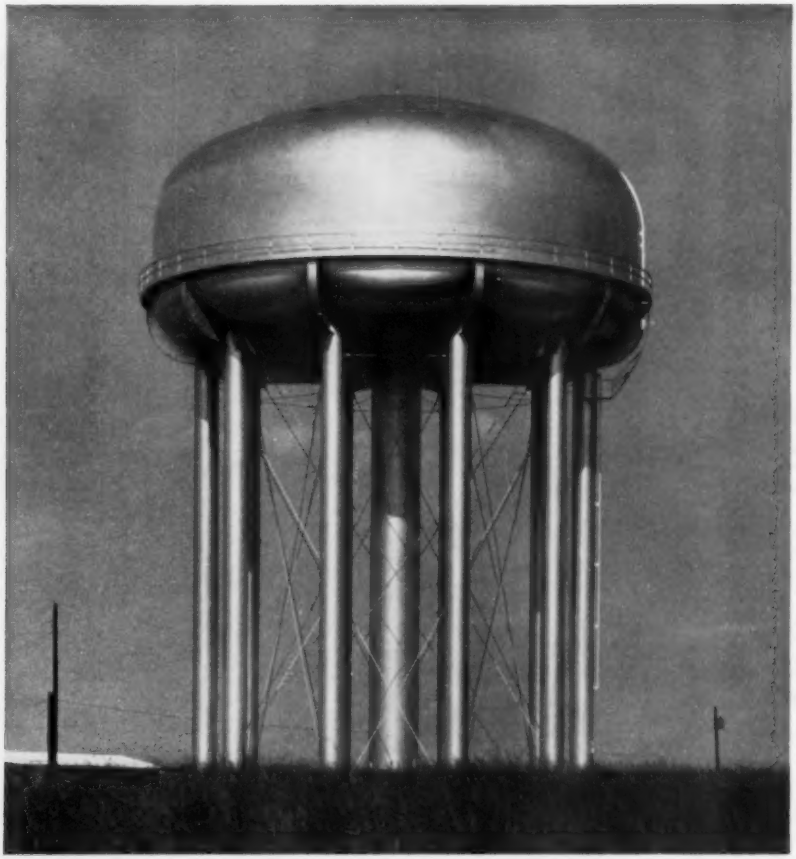
Guidance in the selection of the right equipment – and its use – is offered by the "Flexible" representative in your territory.

Write for the name of your representative for the full story on "Rodding Water Mains the 'Flexible' Way," or, if you prefer, ask for Catalog 55-B and the Pipe Cleaning Manual.

Flexible INC.

3786 DURANGO AVE., LOS ANGELES 34, CALIF.
(Distributors in Principal Cities)

AMERICA'S LARGEST LINE OF PIPE CLEANING TOOLS AND EQUIPMENT



Radial Cone Tank at Arlington, Texas

This 1,000,000-gallon radial cone tank was built for the City of Arlington, Texas, to provide a reliable gravity water supply for the City. In 1951 a Horton Reservoir and Horton Ellipsoidal Elevated tank were also built by Chicago Bridge & Iron Company for Arlington.

The radial cone tank is 75 feet to the bottom capacity line and has a range in head of 30 feet. For information or quotation write to our nearest office below.

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Plants in Birmingham, Chicago, Salt Lake City and Greenville, Pa.

BIRMINGHAM	NEW YORK	ATLANTA	SALT LAKE CITY
PHILADELPHIA	HOUSTON	BOSTON	SOUTH PASADENA
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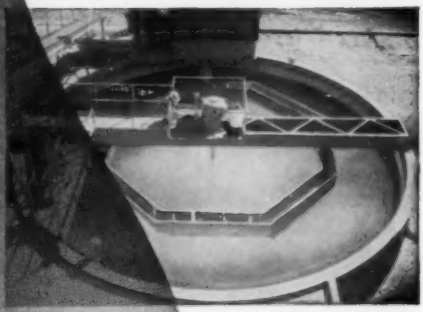
CHICAGO	DETROIT	CLEVELAND	NEW ORLEANS

In Canada—HORTON STEEL WORKS, LIMITED, FORT ERIE, ONT.

Why General Filter?

There are many reasons why municipalities and industries have installed General Filter water treating plants:



INSTALLATION SUPERVISION . . . General Filter "job-engineers" each installation to the consulting engineer's specification . . . supervises the installation and trains the personnel who will work with the equipment.

OPERATIONAL DEPENDABILITY . . . for twenty years General Filter has concentrated all of its efforts toward "better water treatment". Their efforts have produced water treating plants and equipment that are *completely* dependable.

ENGINEERING KNOW-HOW . . . General Filter's design and construction engineers are familiar with the problems involved in water treatment.

GREATER ECONOMY . . . the only real test of economy is a long term test. General Filter plants stand up over the years providing "better water" with minimum maintenance, longer trouble-free, smoother operation.

Find out why you should specify General Filter . . . Write today for detailed information regarding your water treatment problems.

General Filter Company
AMES, IOWA
. . . *better water*

AERATORS • FILTERS • TASTE AND ODOR • ALKALINITY CONTROL • HIGH CAPACITY
FERROUS ZEOLITE • IRON RUST REMOVAL • DEMINERALIZATION • SOFTENERS

Reduce Valve Costs by Using

CLASS A or B

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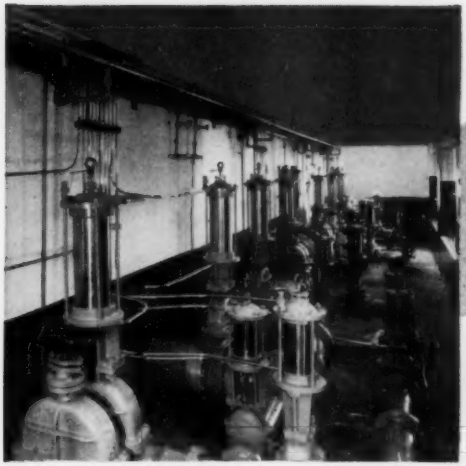
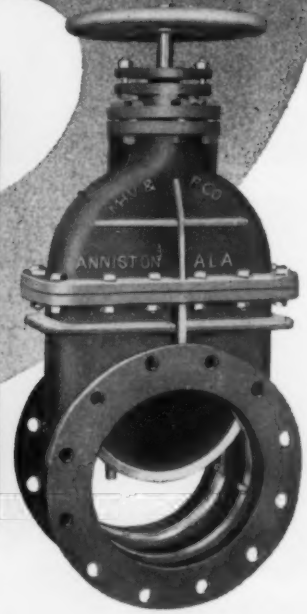
FOR LOW PRESSURE SERVICE





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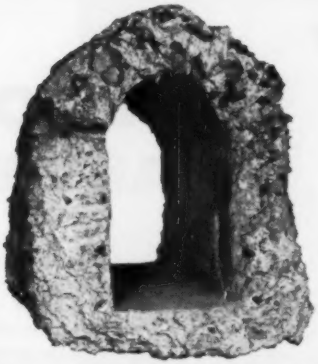

CONCRETE FACT — This is a section of the Roman aqueduct between Eiffel and Cologne, built in 80 A.D., in use continuously until 1928. A natural cement occurring along the Rhine between Cologne and Coblenz was used by Roman army engineers in building the aqueduct. (Photo, courtesy Smithsonian Institute, Washington, D. C.)

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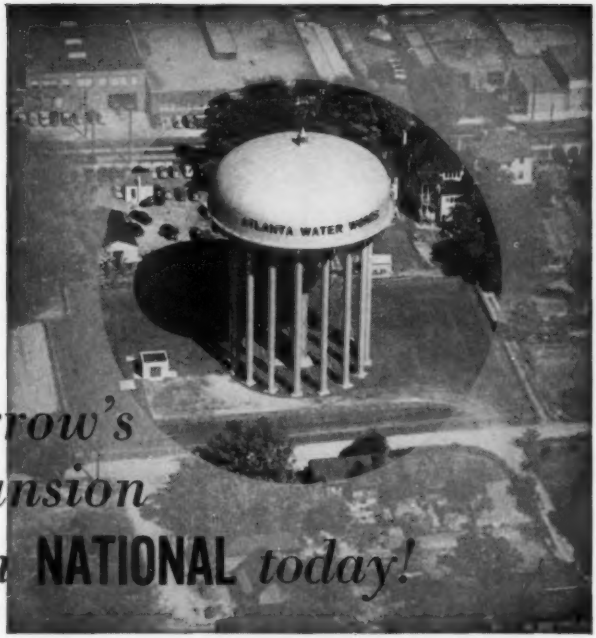

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a few plain words about...

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The Ford Yoke dates back to 1911. Its outstanding success resulted in a wide variety of meter holding devices called yokes. But the Ford yoke as now made offers advantages not obtainable in any other type of meter setting. Millions are in use.

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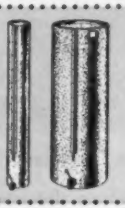
Before Ford Calibrated Testing Tanks were put on the market about 35 years ago, such meters as were tested were checked against gravimetric scales, which were complicated and inconvenient. Thousands of Ford Tanks are in service, in sizes from one to 1000 gallons.



METER VALVE

The Meter Valve is a close-coupled combination of an inverted key valve and a meter connection. It saves material, pipe joints and space in the meter setting. Ford Meter Valves bear the trademark name of Ringstyle Valves.

THE KORNERHORN

In a vertical basement pipe, against the wall or in a corner, the Kornerhorn makes a most satisfactory meter setting. Installation is fast and economical as pipe threading is eliminated. Send for detailed information.

Meters can *earn* real money. In most water utilities they measure and determine *all* the income.

It is good business to accord meters the treatment they deserve as valuable equipment and as sources of revenue. Such enlightened treatment includes settings which provide protection, easy availability for reading, and trouble-free meter changes for proper maintenance.

For 60 years our company has served thousands of water utilities in providing better water meter settings. Submit *your* problems to Ford.

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

WABASH, INDIANA

FORD

New Cochrane SOLIDS-CONTACT REACTOR

combines

mixing, precipitation, sludge concentration, clarification & softening

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Cochrane's background in water conditioning makes possible the installation of complete systems under a single responsibility for continued, consistent performance. Write for Publication 5001-A and case history reprints.

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- **Strength, durability, and corrosion-resistance assure long trouble-free service.**

Specify American Cast Iron Pipe. A call to our Sales Office nearest you will bring both information and assistance.

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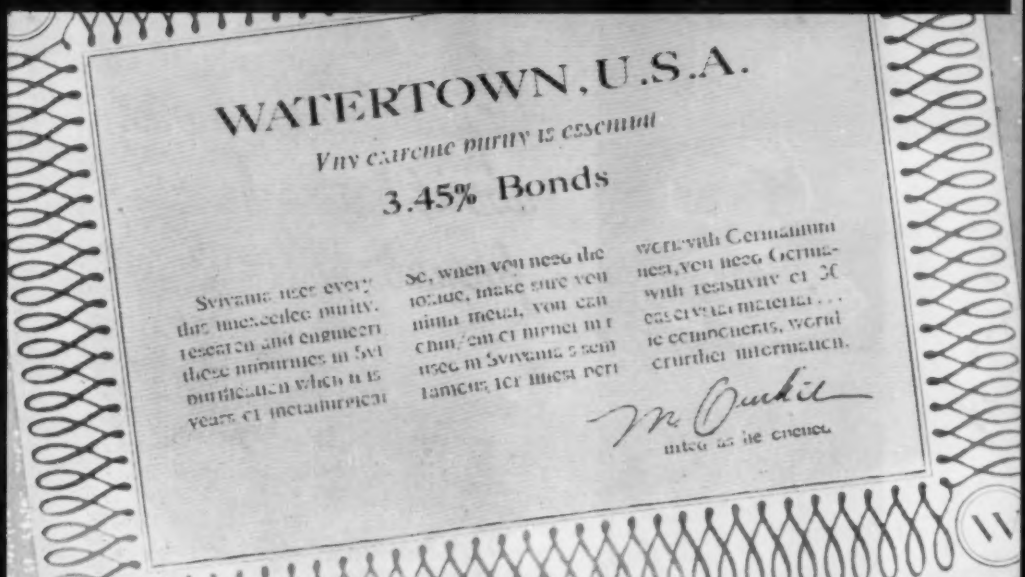
WITH CELITE DIATOMITE FILTRATION
YOU CAN GET CRYSTAL CLEAR WATER AND...



Cut capital filtration costs as much as 45%

An actual installation by Johns-Manville established that a Celite* filter station can be constructed for 55% of the cost of a comparable sand filter plant.†

Diatomite systems not only cut costs, but, under comparable conditions, they also improve water clarity. For with Celite, turbidity is usually lower since more suspended impurities, including all floc, amoebae and algae, are removed. In fact in some cases, turbidity is so low it can't be measured.

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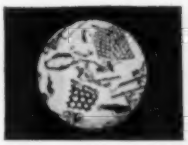
Mined by Johns-Manville at the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is available in a wide range of grades to deliver the best practical balance of clarity and flow rate with any suitable filter. For further information see your nearby Celite engineer or write for free technical reprints and illustrated brochure to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.



Celite filter aids are composed of microscopic, irregularly-shaped particles like these. 90% of a given quantity of Celite is composed of countless channels and voids that trap the finest impurities while permitting the free passage of clear liquid.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products. †See *Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956, or write for free reprint.

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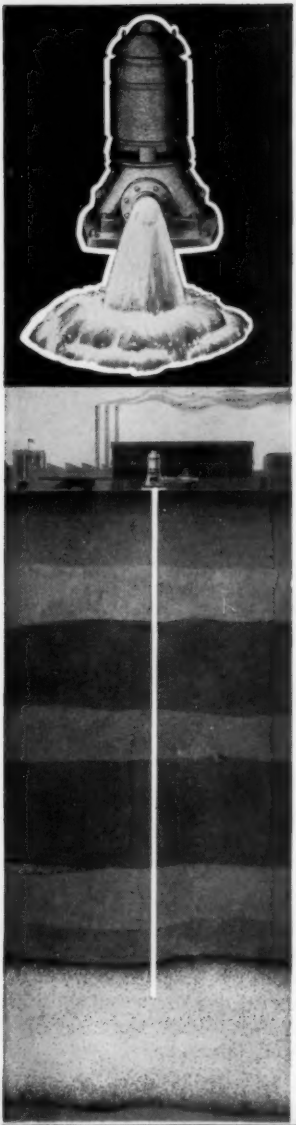
Johns-Manville CELITE Filter Aids



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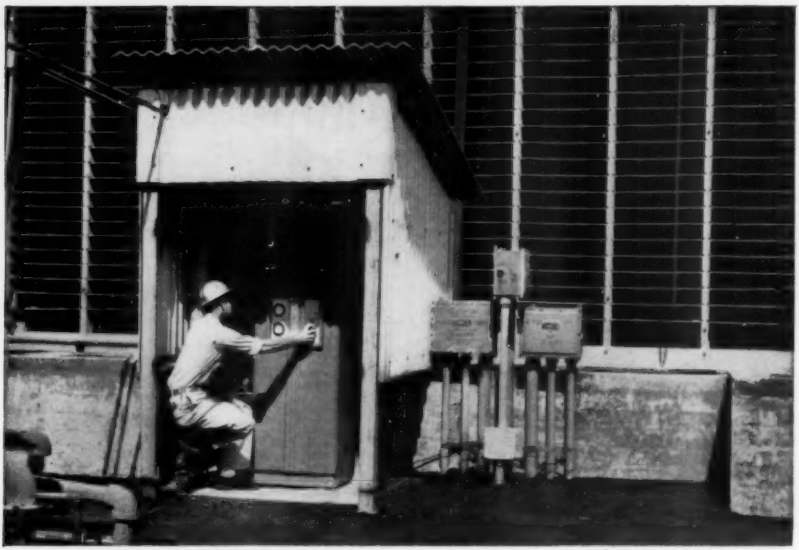

W&T V-notch Chlorinator at Esso's Baton Rouge Refinery feeds chlorine at rates up to 500 lbs./24 hr. over a 10 to 1 feed range. Other V-notch models are available with maximum capacities from 500 to 2000 lbs./24 hr. over a 20 to 1 feed range.

NEW W&T V-NOTCH CHLORINATORS,

are rugged—easy to operate —moderately priced

The W&T V-notch Chlorinator installed at the Esso Standard Oil Co. Refinery, Baton Rouge, La. is housed in a shed open to the sun, weather, and water spray drifting from a cooling tower. The average water or sewage treatment plant operator would consider this rugged service for any piece of equipment.

W&T V-notch Chlorinators have proven in this and other installations that they can withstand rugged service. The design of new V-notch Chlorinators uses not only modern corrosion proof materials but a new concept of chlorine gas control, the W&T V-notch Variable Orifice. V-notch Chlorinators are easy to operate and maintain. They provide the precise chlorine control that is expected from Wallace and Tiernan equipment. In addition, W&T V-notch Chlorinators are an attractive piece of equipment, colored soft green to fit into plant color schemes.

Ask your local W&T representative for more information about W&T V-notch Chlorinators or send for Bulletin S-114.

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • MARCH 1957 • NO. 3

Forecasting Water Requirements for Distribution Systems

Joint Discussion

A joint discussion presented on Oct. 25, 1956, at the Chesapeake Section Meeting, Baltimore, Md.

—Forecasting Residential Requirements—*Jerome B. Wolff*—

A paper presented by Jerome B. Wolff, Deputy Chief, Bureau of Eng., Dept. of Public Works, Baltimore County, Towson, Md.

OF particular interest to this discussion are those areas which contain residential communities. The residential and commercial demands have been examined separately from industrial demands—a difficult task which calls for considerable judgment in the analysis of data.

The data presented here indicate that there has been a substantial increase in per capita consumption during the great home building spurt of the past 10 years. Peak daily and hourly consumption have also shown a pronounced upward trend. These three classes of demands are of special interest to the designer, and have been the subject of investigations catalogued in this article.

The per capita increase in the use of water is no surprise. The home use of additional water-consuming devices such air conditions, lawn sprinklers, dishwashers, washing machines, and garbage grinders in addition to the usual home plumbing installations is increasing each year. The market for these items is continuing to expand. A market study completed by the electrical industry in 1954 (*1*) indicated that the purchase of electrical appliances has been growing at a much faster rate than the growth of disposable personal incomes. This was not the case prior to 1945, and the two rates were virtually identical between 1929 and 1941. In the case of water-consuming electrical devices, it has been found that only 25 per cent of homes have automatic washers, 10 per cent have garbage grinders and dishwashers, and less than 5 per cent have water-cooled air conditioners.

There were approximately 48 million dwelling units in the US in 1955. Projecting the current building rate of 1 million per year for 10 years, the number of dwellings which will be

erected by 1965 will reach 58 million, an increase of over 20 per cent in 10 years. This anticipated rate of building will swell the use of water-consuming devices, and at an accelerated pace, since the new homes contain many more water-using fixtures than 20 years ago.

Simultaneous use of many domestic water-consuming devices, particularly lawn sprinklers, and air conditioners, has dramatically increased peak consumption during the past 10 years. All signs point to a continuing increase in average consumption as well as maximum usage for an indefinite time—certainly as long as the trend toward suburban living continues.

Population and Water Use Data

It is of interest to examine the trend of growth and expected water consumption for the country as a whole. Figure 1 shows curves representing expected growth of population served by public water supplies, daily average water use, and per capita usage for 1940–1975. These curves are based on data developed by Picton and Levie (*2*). It is estimated that by 1975 the total population of the US will exceed 200 million. The population served by public water supply facilities has increased from 82 million to 111 million between 1940 and 1955 (a 35 per cent increase). Usage of public suplies has increased from approximately 125 gpcd in 1940, to 155 gpcd in 1955 (a 24 per cent increase). The usage in 1975 is estimated at 200 gpcd (a 29 per cent increase for 1955–1975). The insert in Fig. 1 shows that the estimated rate of per capita increase lags behind the expected population served. It is estimated that between 1955 and 1975, the population

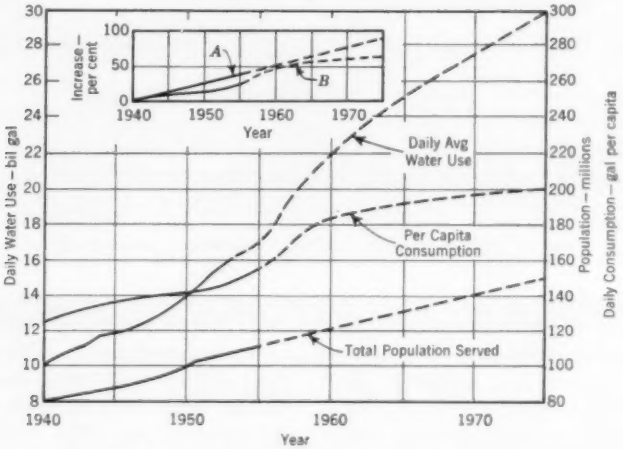

Fig. 1. Public Water Used and Population Served

The dotted curves indicate expected growth. The insert represents a comparison of projected increase to population served and per capita water use. The population increase (Curve A) is 2.4 per cent per year, and the per capita annual increase of water use (Curve B) is 1.9 per cent.

served will increase at an average rate of 2.4 per cent per year (base year, 1940), while the per capita usage will increase at an average rate of approxi-1.9 per cent per year. It is assumed that per capita consumption as well as population will increase at a lower rate after 1960. The above water-consumption data reflect combined public demands—residential, commercial and industrial.

The Baltimore metropolitan area averages compare very closely to the national one. In 1955 the raw-water demand in the Baltimore area was 153 gpcd. For the same year, the national average consumption in area served by public water supplies was 155 gpcd. Between 1940 and 1955 the raw water per capita demand in the Baltimore metropolitan area increased an average of 1.9 per cent. The projected rate of increase of per capita consumption for the Baltimore metropolitan area during the period 1955–1975 given by the Board of Advisory Engineers on Future Water Supply (*3*) is 0.8 per cent per year (considerably below the projected national average).

An examination of public water usage in predominantly residential areas is rather difficult, as was stated earlier, because of the difficulty in segregating accurately residential consumption and other demands. It is possible, however, to obtain information which can be used safely as a general guide in estimating residential consumption.

Per capita water consumption and population information available for eighteen residential areas ranging in population from 4,000 to 163,000 is presented in Table 1. Most of the areas included in this table are metered, and residential consumption constitutes 70–100 per cent of the total demand. In 1955 the consumption for these communities varied from a low of 53 gpcd to a high of 114 gpcd. The average per capita consumption in 1955 was 82 gpcd. This table indicates that the per capita consumption has grown at the rate of 2 per cent per year for the past 10 years, which coincides with the per capita growth in the three residential communities in the Baltimore suburban area (Catonsville, Pikesville and Towson).

It will be noted that the per capita increase of 2 per cent per year for residential communities is only slightly higher than the increase in per capita consumption shown on Fig. 1, which indicated an overall growth for the nation of 1.9 per cent per year since 1940 for all public uses, including industrial and commercial demands.

It has been recommended that for the 20 year period from 1955–1975, an annual increase of 2 per cent per capita per day be utilized for the design of residential water distribution systems because of the great potential for increased utilization of water-consuming equipment in homes.

Modifications must be made in the use of these data; in suburban developments having large lots, the per capita water consumption will reach as high as 125 gpd, whereas older neighborhoods with small lots or apartment dwelling units will consume only 65 gpcd (4, 5). On the basis of average use, however, 82 gpcd for residential areas in 1955 is considered adequate. Calculating an incremental growth in percentage of per capita consumption rather than a fixed incremental quantity per year is recommended, as the use of percentage growth reflects more accurately the individual characteristics of the area studied. It should be emphasized that the per capita consumption always decreases with the widespread use of metering in the areas

studied. It has been assumed in this discussion that the areas to be served will have a high degree of metering; if this is not the case, a considerably higher per capita consumption must be assumed.

Peak Daily Demands

An examination of data in the Baltimore metropolitan area indicates that a sharp rise in maximum or peak daily consumption is occurring. Pumping charts in three residential communities in Baltimore County, for example, have shown that, since 1945, the ratio of maximum to average day's pumping has increased from 156 to 200 per cent in Towson; from 154 to 190 per cent in Catonsville; and from 141 to 182 per cent in Pikesville. The trends of maximum demands in Baltimore city and the three predominantly residential areas mentioned are shown in Fig. 2. For the purpose of this analysis, the effect of all data subsequent to 1945 was evaluated. Least squares * were applied to these data and a linear regression line was developed to represent the individual trends. It can be seen that the rate of increase of the ratio of peak to average day was 0.9 per cent per year during the past 10 years for the entire Baltimore area, while a much higher rate, varying from 1.3 to 4.3 per cent per year, has been experienced in the residential areas.

Since these peaks are increasing at a faster rate than was estimated in an earlier report on the Baltimore City and County Water Distribution System (6), it was determined that information from other communities would be useful to corroborate the Baltimore area trends. In water distribution sys-

TABLE 1

*Per Capita Consumption of Various Cities**

City & State	Pop. *1,000's*	1955 *gpcd*†	Yearly Increase %	Years Recorded	Restrictions	Consumers‡
Mays Landing, N.J.	4.0	63	3.8	6	None	R
Suffolk, N.Y.	6.0	83	−2.0	7	None	R & C
Wellsburg, W.Va.	6.5	79	—	1	None	R, C & I
Fairfax, Va.	7.5	69	2.0	4	Sprinkling	R & C
Circleville, Ohio	11.1	74	2.0	6	None	75% R; 10% C; 15% I
Indiana, Pa.	12.0	82	—	1	None	70% R; 10% C; 20% I
Norwalk, Ohio	12.0	84	0.5	10	None	74% R; 14% C; 12% I
Delaware, Ohio	14.0	91	1.0	6	None	R
Catonsville, Md.	16.0	77	2.0	10	Sprinkling	R & C
Rockville, Md.	17.6	91	—	1	Sprinkling	R & C
Woodbury, N.J.	22.0	86	1.8	10	None	85% R; 12% C; 3% I
Pikesville, Md.	22.0	76	2.0	10	Sprinkling	R & C
Lancaster, Ohio	26.5	102	2.5	10	None	R, C & I
Ann Arundel County, Md.	36.4	53	1.0	10	Sprinkling	80% R; 20% I
Salem & Beverly, Mass.	40.1	114	0.0	10	None	R
Towson, Md.	45.0	80	2.0	10	Sprinkling	R & C
Levittown, Pa.	49.0	74	3.0	4	None	99.4 % R; 0.4% I
Arlington Co. Va.	162.5	102	3.8	10	None	R & C
Average		82	2.0			

* In areas of 80 per cent and more metering.
† Gallons per day per capita.
‡ Residential—R; Commercial—C; and Industrial—I.

* The principle of least squares aids in determining a line which best fits a trend in a time series analysis.

tem design, it is of paramount importance to keep abreast of current trends in maximum daily consumption.

results from fixed charges, the effect of the maximum day's use on capital outlay is directly reflected in the cost of water.

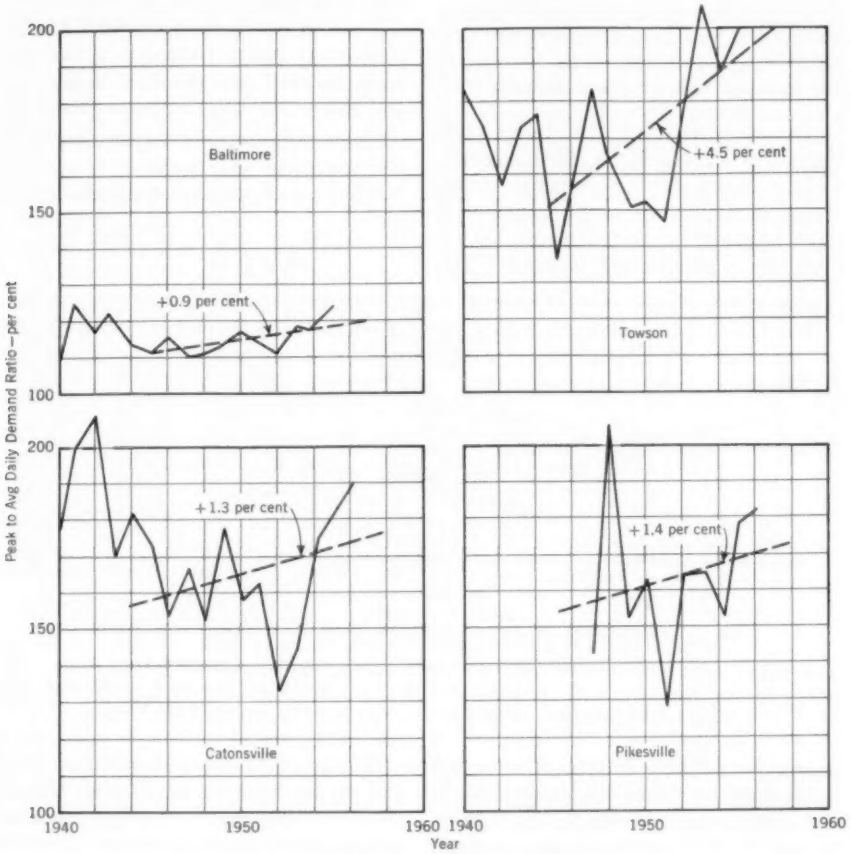

Fig. 2. Ratio of Peak to Average Day's Demand

The graphs show clearly the difference between suburban and city demands.

Louis R. Howson, in his report of the Chicago water distribution system (*7*) stated:

Although the average day's use is the basis of revenue, it is the maximum day's requirement that is the measure of adequacy and that determines capital expenditures. Because, in general, approximately 50 per cent of the cost of water

At Chicago, as elsewhere, recent years show a marked rise in the ratio of the maximum day to the average day and of the maximum hour to the average day. The ratios at Chicago in comparison with many other cities are still low. The ratio of the maximum day to the average day at Chicago has increased almost 1 per cent per year for the last 10 years and is now approximately 150 per cent. Dur-

ing the same period, the ratio of the maximum to the average hourly requirement has increased 1½ per cent yearly and is now approximately 175 per cent. It is believed that these ratios will continue to rise at Chicago even though the suburban supply is restricted by contract to the average rate of the maximum day.

To obtain data for this study, questionnaires were sent to 300 communities in eleven Middle Atlantic states. Approximately 100 communities supplied information and, of those, 70 replies were considered usable.† The population of these communities varied from 4,000 for Mays Landing, N.J., to 3.5 million for the Bronx and Manhattan, N.Y. Information on average and maximum water consumption for the past 15 years was obtained from these cities. Residential usage of water varied from 30 to 100 per cent of the total consumption. The percentage of metering in these cities also varied greatly.

Using ungrouped data for the cities and communities reporting, it was found that a relation existed between the total population of the area served and the percentage ratio of the maximum to average day's consumption of record during the past 10 years.

Least squares were applied to the percentage ratio data for residential areas as well as combined residential and industrial areas. Regression lines were determined which fitted logarithmic functions quite well.

The general form of equation used is:

$$\log y = \log a + b \log x$$
$$\text{or } y = ax^b$$

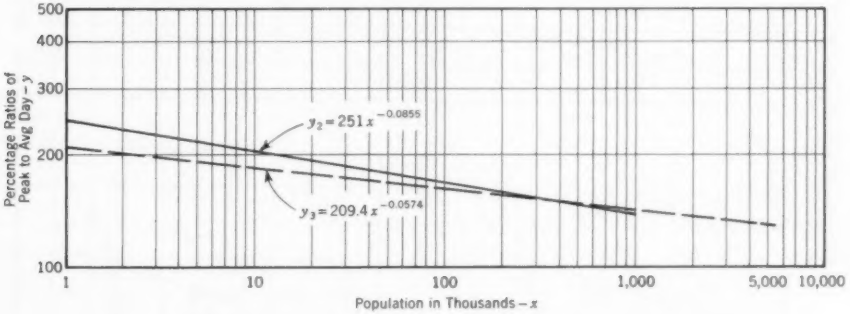

Fig. 3. Correlation of Population and Peak to Average Day Ratio

The upper solid curve represents the peaking experience in residential areas; the lower dashed line shows the peaking in composite areas having both residential and industrial demands. A key to the equations is given in the text.

The trend lines are shown in Fig. 3. On the basis of the application of normal equations to the data, the proposed equations for these lines are:

$$y_2 = 209.4x^{-0.0574} \ldots \text{(Eq 1)}$$

for combined residential and industrial areas; and

$$y_3 = 251.0x^{-0.0855} \ldots \text{(Eq 2)}$$

for residential communities where y_2 and y_3 are percentage ratios of maximum over average day's demands for the communities already mentioned, and x is population in thousands.

The standard error of estimate for Eq 1 and 2 amounts to a percentage

† Location of Communities by states: Conn.—3; Md.—12; Mass.—5; N.J.—5; N.Y.—13; Ohio—8; Pa.—10; R.I.—2; Vt.—1; Va.—6; W.Va.—5.

ratio of 2.3. Three standard errors of estimate, from the computed value (which should include 99.7 per cent of all the data on the basis of a normal distribution about the line of regression) will therefore result in a total percentage ratio variation of plus or minus 7.0.

By the use of grouped data for the cities and communities reporting, it was found that a relation also existed between the size of the city and the rate at which the percentage ratio of maximum to average day's consumption is increasing. This is shown in Fig. 4, and is summarized in Table 2. For cities with populations less than 10,000, the percentage ratio increase is more than 4 per cent per year; for cities with populations in the 10,000–25,000 range, the increase is 2 per cent per year; for cities with 100,000–250,000 population, the percentage ratio increase is 1.6 per cent per year; and for cities exceeding 250,000, it is approximately 1 per cent per year. A great deal of dispersion in the data was discovered, as can be seen in Table 2. No correlation could be found between the rate of growth of the areas and the rate of increase in the ratio of maximum to average day's consumption.

The average annual increase in the percentage ratio of maximum to average day's consumption for the 52 communities on which a mathematical analysis could be applied, amounts to 1.92. The use of an average increase is not recommended as there is clearly a relation between the population of the community and the rate of increase of the ratio of maximum to average day's demand. The yearly increase for those communities with population less than 50,000 is equally applicable to residential and combined industrial and residential areas. Insufficient data from which any distinction could be made in the groupings cause this. Large communities, with the notable exception of the Western and Eastern Third Zones in the Baltimore system and Arlington, Va., have mixed industrial and residential demands. It is believed that the increases given in Fig. 4 and Table 2 will continue as a linear progression until at least 1975.

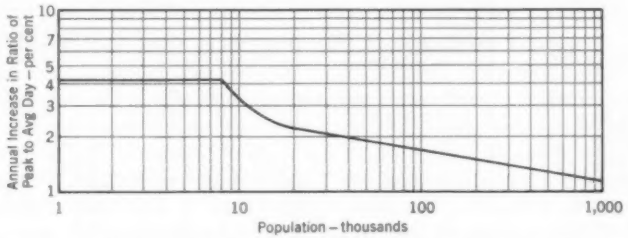

Fig. 4. Correlation Between Population and Annual Increase Percentage Ratio of Peak to Average Day's Demand

The following simple example will demonstrate how the curves shown in Fig. 3 and 4 can be utilized:

Given an estimated 1975 population of community as 100,000, and assuming that the community is predominantly residential, with some commercial properties, then either Curve y_2 or Eq 2 is used to determine the percentage ratio of peak day to average day's consumption. For a 100,000 population the ratio is 170 per cent, to which must be added 7 per cent to obtain the greatest deviation. The resulting ratio of 177 per cent is the 1955 figure.

This curve is then entered in Fig. 4 or Table 2, to read 1.8 per cent per year. For 1975, the total percentage ratio will be the sum of 177 per cent and 36 per cent or 213 per cent. This percentage ratio is then applied to the estimated per capita consumption for 1975.

The per capita consumption in 1975 will be 82 gpd plus 82 gpd times 20 years times 2 per cent per year or 115 gal for the average day. The peak day's consumption per capita will then be 115 times 2.13, or 245 gpd.

ratio increase is recommended. This ratio of growth will apply to large eastern cities such as New York, Philadelphia and Baltimore. All of the data presented here are recommended for use in the Middle Atlantic states.

It should be observed that 22 out of the 70 communities studied have already experienced peaks of 175 per cent on average days. Fourteen of these 22 have already had peaks 200 per cent over the average daily use. It is obvious that general trends are useful but that many individual areas vary

TABLE 2

Relation of Population Served to Increase Percentage Ratio of Peak to Average Daily Consumption

Population—*1,000's*	Annual Increase Percentage Ratio*	No. of Cities	Total range of annual values—%	
			Decrease	Increase
Under 10.0	4.3	6	−4.0	+10.0
10.0–25.0	2.1	9	−0.7	+ 8.0
25.0–50.0	2.0	6	−0.3	+ 4.5
50.0–100.0	1.8	5	+0.5	+ 4.0
100.0–250.0	1.6	11	−0.7	+ 2.7
250.0–500.0	1.4	6	+0.8	+ 4.3
500.0–1,000.0	1.0	3	0.0	+ 1.5
Over 1,000.0	1.0	7	+0.9	+ 1.2
Avg. Increase	1.92	53		

*Grouped data.

In the Baltimore area, application of this yearly peak percentage ratio would show a 30–60 per cent average growth between 1955 and 1975. Since the average percentage ratio is about 190 in the three suburban communities of Towson, Pikesville, and Catonsville (Fig. 2), the ratio can rise to as high as 250 by 1975. It is suggested that this trend may become asymptotic some time before 1975, but it is recommended that the straight line trend be used because of the spectacular growth in demand now indicated.

For large mixed residential and industrial areas an annual 1 per cent

considerably from the norms indicated here. The application of the percentages suggested here must be done with careful judgment by the designer; he must consider all of the many variables affecting residential growth in his community.

Peak Hourly Consumption

It does not require a careful scrutiny of the records to arrive at the conclusion that hourly peaking of distribution systems has become an acute problem. Of 70 communities which reported, 28 (40 per cent) have had to resort to some form of water-use

restrictions during peak days. A number of others reported difficulty in supplying peak hourly demands, but have not resorted to restrictions. Experience in the Baltimore metropolitan area is typical of the conditions experienced in larger metropolitan areas where the phenomenal growth of suburbs has so overworked the existing central system and peripheral portions of the area that an entirely new examination has had to be made of the water distribution system. It is difficult to obtain dependable peak hour data on which design can be based. The little information obtained makes it clear that more data must be secured on the phenomena of water use habits in residential neighborhoods.

Present experience leads to the conclusion that widespread use of surcharge rates for air-conditioning and lawn-sprinkling demands is not far away. A number of cities have already adopted surcharges for the use of air conditioning and others have made the use of water conservation equipment mandatory for all installations having air conditioners with capacity exceeding 2–3 tons. Interest in the use of demand meters instead of the recording meters which are now in vogue is growing. Demand meters are expensive but they may become necessary if the trends in hourly peaking continue.

A study which Baltimore County completed in 1954 indicated that demands in residential neighborhoods vary from six to twenty times the average daily use, depending on the type of neighborhood. The greater the lawn areas, the higher were the hourly peaks.

Where communities are located in the temperate zone and experience hot summers, the trend towards the use of complete air conditioning in homes has been very pronounced. There is evidence from recent studies that this class of water consumption has a very unfavorable influence on maximum demands because of lack of diversity. St. Louis has found that it costs from six to nine times as much to provide additional pumping and treatment facilities for the extra water demands of air conditioners as it cost to provide water conservation equipment (*8*). Although there is a considerable diversity factor in the use of lawn sprinkling, as 20–40 per cent of the residential areas use lawn sprinklers during peak hour, all of the residential air conditioners are in operation on hot days. Thus, residential air-conditioning use is superimposed on lawn-sprinkling demand.

It has been estimated that water-consuming air-conditioning installations can rise from their present 8 per cent of total water use to more than 50 per cent (in some larger cities) of the total water use on peak days by 1960. In a number of cities today, it was estimated (*9*) that peak daily demands increased from 5 to 50 per cent, with an average increase of 20 per cent, due to the air-conditioning load alone (*8*).

A 1954 hourly demand study in Baltimore County (*5*) suggested the following:

1. In older neighborhoods, well settled, with small lots, the peak hour demand might be 500–600 per cent of the average daily demand.

2. In newer neighborhoods with average size lots ($\frac{1}{4}$–$\frac{1}{2}$ acre), the ratio of peak hour demands to average demand is 900 per cent.

3. In new and old neighborhoods with large lots ($\frac{1}{2}$–3 acres), the ratio is 1,500 per cent.

Data on maximum hourly consumption in fourteen communities varying in population from 16,500 (Salisbury,

Md.) to 3.5 million (Manhattan and Bronx, N.Y.) are given in Table 3. Shown clearly is the fact that for cities in the 30,000–40,000 population range having a high percentage of residential population, peak hours are sometimes as much as 1,000 per cent of an average day's consumption. This table also shows that there is an inverse relation between population and the percentage ratio of peak hour to average day, but the amount of information now available is entirely too scanty to make a mathematical analysis.

has been demonstrated in the result of fire flow tests made in a number of new communities. . . .

It was also determined in Baltimore that fire flow demands do not govern distribution system design where heavy peak hourly consumption is imposed. The experience in three predominantly residential areas with population ranging from 15,000 to 45,000 was that the use of peak hourly flows representing 400–500 per cent of the average daily usage, reflects more accurately the hourly demand experienced for the

TABLE 3

Percentage Ratio of Peak to Average Day for Various Cities

Restrictions	City & State	Highest Year of Record	Population *1,000's*	Ratio Peak Hour to Average Day %	Type of Consumers*
No	Salisbury, Md.	1954	16.2	430	R; C; I
No	Levittown, Pa. (*9*)	1954	30.0	1000	99.4% R; 0.6% C
Yes	Long Island, N.Y. (*9*)	1953	30.0	500	R
Yes	Towson, Md.	1954	38.3	376	R; C
Yes	Schenectady, N.Y.	1954	111.7	420	51% R; 10% C; 38% I
No	Springfield, Mass.	1955	168.8	266	46% R; 19% C; 36% I
Yes	Richmond, N.Y.	1953	203.0	265	R; C; I
No	Providence, R.I.	1954	372.0	312	33% R; 13% C; 54% I
No	Indianapolis (*10*)	1954	450.0	243	R; C; I
	Central	—	—	205	C; I
	East	—	—	299	R; I
	North	—	—	401	R
Yes	Baltimore, Md.	1953	1,246.0	168	R; C; I
Yes	Queens, N.Y.	1953	1,718.0	174	R; C; I
No	Philadelphia, Pa.	1953	2,150.0	175	52% R & C; 48% I
Yes	Brooklyn, N.Y.	1953	2,738.0	181	R; C; I
Yes	Manhattan & Bronx, N.Y.	1952	3,447.0	190	R; C; I

* Residential—R; Commercial—C; and Industrial—I.

It has recently been pointed out (*11*) that:

In the new small communities and in the suburban areas of large cities it has already been stated that peak hourly demand may exceed six times the average daily rate. This means that the peak hourly rate rather than the fire flow and the maximum daily consumption rate should control the design, a fact which

system as a whole. The much higher peaks presented in Table 3 should indicate the expected demands in predominantly residential portions of the system.

Conclusion

The effect of rapid population growth on the design and water distribution systems is evident. Systems

must be reinforced with new pumping and storage facilities, new distribution feeders and transmission mains. In general, the older systems must either be completely overhauled or new reinforcements added to them. For the new systems, it is believed that radically new design concepts must be considered. From the data presented above, it is clear that the growth and water use characteristics of all communities must be carefully reviewed year by year and the trends noted in order that the water supply systems can keep abreast of the ever increasing demands. Certainly with great plant investment, load forecasting is a necessity. Water utility compare both in value and importance with the electrical industry. The water works industry should place more emphasis on the problem of making year-to-year forecasts of loads as is now done in the power industry.

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—Forecasting Industrial Requirements—*M. Joseph Willis*—

A paper presented by M. Joseph Willis, Asst. Prof. of Civil Eng., Swarthmore College, Pa.

The following discussion deals with the effect of industrial loads on the water distribution system of a large metropolitan area. The methods of study used to predict industrial loads are thought to be applicable to any size distribution system where industrial consumption is an appreciable part of total consumption.

Aspects of Growth

The increasing use of water in industry has been reported in a number of articles since the war. In March 1953, a task group of the AWWA (*1*) reported that of about 200 bgd of water used in the US for all purposes, irrigation required about 100 bgd, industrial use from private sources was

about 81 bgd, and municipal and rural use accounted for about 19 bgd, of which about 7 bgd was purchased by industry. Thus, total industrial use, including cooling water, is about 88 bgd. If water used by industry only for cooling is not counted, industrial consumption is about 21 bgd and, thus approximately double public municipal use.

The rapidly increasing use of water for industrial purposes has been studied by the President's Materials Policy Commission (Paley Commission), which reports an approximate 40 per cent increase in total water consumption in the years 1942–1952, and predicts that there will be a 90 per cent increase in water consumption in the 1950–1975 period. The ratio of industrial water use to total use is also expected to increase from about 40 to 60 per cent of total consumption.

Uses of Industrial Water

Industrial water consumption is far more important than the rather scant attention in the literature would indicate.

A striking characteristic of industrial water use is the relatively small amount of water included in the manufacturing process or lost by evaporation compared to the quantity passed through the plant. Most waste waters can be reused after treatment.

Another interesting and important characteristic of industrial water use is that 80 per cent of industrial water is consumed by about 5 per cent of the industrial plants, while nearly 70 per cent use less than 2 per cent. The major water-using industries are steel, petroleum products, wood pulp and paper, coke, and milk, beverage, and ice producers. These industries were reported to be using 21 bgd in 1950.

The AWWA task group report of 1953 (*1*) classified industrial water use under seven major headings: [1] cooling; [2] solvent; [3] catalyst; [4] conveying medium; [5] plant cleansing agent; [6] production and distribution of heat and power; and [7] for worker use and as a lubricant. Cooling water, accounting for about 3 of every 4 gal used by industry, constitutes by far the greatest single use category, and usually does not require a water of high quality. There appears to be very little available information on the quantities of water used under the other categories.

Acute Problems

The nationally available water supply greatly exceeds the demand, a situation expected to continue for a long time in the future. In many localities, the problem of obtaining adequate water supplies has become so acute that numerous articles have appeared in nontechnical magazines discussing "dwindling" water resources and the increasing load of half-treated waste waters dumped into natural watercourses.

The bases of industrial water supply problems have been listed by Abel Wolman and the author (*2*) in the following manner:

1. *Delay in execution*—Historically, there is usually a 10–15-years lag from the initial conception to the final execution of a municipal work of any magnitude; this applies generally to water works improvements throughout the country.

2. *Deficiencies in distribution*—The distribution system is often the cause of a community's water difficulties, particularly when an older central city is supplying a rapidly expanding peripheral area. The problem is further exacerbated by the tendency of new in-

dustries, often large water users, to settle in metropolitan areas where labor, materials, transportation facilities, and markets are readily available. From the point of view of water supplies alone, large water-using industries should be far removed from metropolitan areas.

3. *Absence of social organization*—An organization for development of water supplies is often nonexistent, as is legislation aimed at the creation of water districts. The "water district" plan has been used very little. Where no public supply is available, industries could conceivably cooperate to develop water supplies, but this plan has been little followed except in Germany.

4. *Reuse of water*—Reuse of water has been little practiced because of cost and technical difficulties. It is gathering supporters, however, especially in areas of severe water scarcity, as in southern California.

5. *Artificial recharge*—Artificial recharge is beset by many technical difficulties and is at present chiefly in the research stage of development.

6. *Reclamation of waste waters*—So far there has been little reuse of treated waste waters; some outstanding examples, however, include Baltimore's Back River sewage treatment plant which supplies about 50 mgd of treated effluent to the Sparrows Point steel mills.

7. *Ground water control*—Administrative and technical control of ground water resources is almost nonexistent in the US. Many industries in the Baltimore area, once heavy users of ground water, have been forced to abandon their wells because of intrusion by water of inferior quality caused by overpumping or by poor well construction practices.

Industrial Load Characteristics

The characteristics of industrial loads differ from those of domestic loads in several major respects.

In an industrial area, the ratio of the peak hourly flow rate to the average annual flow rate is much lower than for a typical residential area. For example, the ratio in Baltimore is about $1\frac{1}{2}$ to 1 for industrial loads, while a typical ratio measured in a Baltimore County suburb is $3\frac{3}{4}$ to 1.

Another unique characteristic of industrial loads is that a concentration of industries in a given area may impose a draft on the distribution system far greater than would a domestic population occupying the same land area.

Few industries use large quantities of water and their exact location on the distribution system is easily spotted. In Baltimore, for example, 69 industries are responsible for nearly all the industrial consumption, and their connections to the distribution system can be accurately determined (seldom practicable with many small domestic and commercial loads).

Industries frequently depend wholly or in part on private well water sources, even in metropolitan areas with adequate municipal water systems. Often, as in Baltimore, the relative importance of private ground water supplies is rapidly changing, and must be evaluated carefully when considering future loads on the municipal system.

In a metropolitan area, land suitable for industrial use is usually well defined, and zoned as such. Thus, on an area basis, predictions can be made more confidently than with domestic and commercial loads which are indefinitely zoned. The task of predicting industrial consumption remains a difficult one, however, for water consump-

tion per acre of area can have a daily range of 500 to 18,000 gal. Wide variations in consumption per acre of plant have often been observed between plants that manufacture similar products. In a California survey, some meat packing plants used six times as much water per unit of area as others; among paper mills, some users required up to 25 times as much as the lightest; and in chemical plants, as high as 50-fold difference has been recorded.

The foregoing factors led to the segregation of industrial loads from domestic and commercial loads in the preparation of the Geyer-Wolff report (*3*).

Geyer-Wolff Concepts

A fundamental concept of the Geyer-Wolff report holds that it is preferable to strengthen the distribution system by building a portion of an ultimate size main than to build a complete but smaller diameter main to serve an intermediate design year. When additional capacity is required, it is cheaper to add to the larger pipeline than to parallel the smaller main with a new one.

In Baltimore, the ultimate design period for the distribution system was set at the year 2000. Before attempting to predict water use that far into the future, present day total and industrial water use were determined to check the reliability of the analytical methods used against known conditions.

In determining industrial water use, the first step was to sort through water meter cards for one billing period in 1953; all accounts using more than 100,000 cu ft per quarter were considered to be industrial loads. As the locations of the industries were known, their water loads were placed directly on a chart of the distribution system and totaled for each zone and industrial area.

Domestic and commercial use in each zone was considered to be the difference between total average annual consumption and the industrial consumption for the zone. The difference was then placed on the system in accordance with the density of population in each census district. In the First Zone, where most industry is concentrated, half of the 106 mgd consumption was attributed to industrial use.

As momentary peak flow rates were required to analyze the distribution system, and the meter cards gave only total consumption for a one quarter billing period, hourly variations in total consumption for each zone were determined from master meters and reservoir level records supplied by the Bureau of Water Supply. Ratios of maximum day to average day and maximum hour to average day flows were selected for industrial water use only. Data for the selection were gathered from Bureau of Water Supply records already mentioned, review of experience in other cities, and information on water-using practices in a group of typical Baltimore industries. In the First Zone, the maximum hourly industrial water use was taken as 1.5 times the average day, and the maximum daily use as 1.2 times the average day.

The related ratios for domestic and commercial use were determined from the assumed variations in industrial use and the known variations in total use within a zone.

While hourly variations in industrial water use were under study, approximately 70 of the largest water-using industries in the Baltimore area were asked for information about their

individual water use characteristics. Among the more significant questions were those about the ratio of peak-hour flow rates to average daily flow rates, the usual time of occurrence of the peak flow, the ratio of water used to product manufactured, and plans for future water use. Peak hour to average day ratios ranged mostly between 1.1 and 2.0. There were a few notable exceptions, such as the canning factories, which gave ratios on the order of 25 to 1. There appeared to be no one time of day when peak flows were most likely, although late morning was frequently reported. Many industries were unable to produce information about peak flow rates; those answering often resorted to timing the readings on a standard water meter.

The data concerning ratio of water used to unit of product manufactured showed that local industries manufacturing the same product used, as a rule, approximately equivalent quantities of water; there was little agreement, however, with data from similar industries in other parts of the country.

The answers to the question about plans for future water use showed that nearly all industries were tending toward less use of private supplies and corresponding increased use of public supplies.

The effect of unaccounted-for water on load estimates was thought to be considerable in the First Zone. It was thought to be part of domestic and commercial consumption.

Because of the inevitable uncertainties in determining the magnitudes of the industrial, domestic, and commercial water loads, and the locations of the domestic and commercial loads, an analysis of the existing system was made to check the agreement of analytical results with actual operating records. Both Hardy Cross and electric network analyzer studies were made of the flows and pressures in the distribution system of each of the lower zones. Hardy Cross studies were made of the higher zones. In every analysis, pressures and flows thus obtained checked with the available field measurements.

Projection of Demands

Future industrial consumption to the year 2000 for the Baltimore water service area was assumed to be equal to the advisory engineer's estimated values for future consumption less estimated totals for domestic and commercial consumption. Domestic and commercial consumption figures were obtained by multiplying predicted population by predicted per capita consumption. For an average day, industrial consumption is predicted as 145 mgd in 1975, and 209 mgd in 2000. In 1953 it was 64 mgd.

Planned future industrial loads were distributed to the various zones of the metropolitan area; in the First Zone, loads were further subdivided among eleven readily distinguishable industrial areas.

Factors which influenced the development of the plans included: zoning maps; areas available for new industry; estimates of future water requirements (supplied by existing industries); information supplied by utility companies; information supplied by railroads owning undeveloped industrial sites; opinions of the Baltimore Association of Commerce and of planning agencies; and the possibilities that industries now using ground water might change over to municipal water as their present supply becomes inadequate or deteriorates in quality.

It was assumed that older industrial areas currently heavy users of water would develop until all remaining land was in use. The Canton district of the First Zone is typical, with a present average day consumption of 15 mgd, and a predicted consumption in the year 2000 of 25 mgd.

Undeveloped areas with industrial potential and now zoned for industry were considered, and future loads (some very large) were assigned. The Marley Neck area, for example, located on the south side of Baltimore harbor and east of the Curtis Bay industrial district, has no present water consumption, but was assigned an average day consumption of 30 mgd in 2000. Calculations were made by multiplying the land area by an estimated water demand per acre. The result obtained is necessarily approximate as water use per acre can range from less than 500 gpd to more than 20,000 gpd. Generally, some information was available about the type of industry to be expected to be developed in an area, narrowing somewhat the anticipated range of consumption.

The ratio of peak to average flow rates in the First Zone was expected to increase from the present 1.5 to 1.65 per cent in the year 2000.

The need to forecast consumption as far into the future as the year 2000, combined with the concept of designing ultimate size pipelines led the authors of the Geyer-Wolff report to recommend that large transmission mains should be built to present and future industrial areas. A study of the report shows that sizes and routes of major reinforcements to the distribution system in the First and Second Zones (where industry is concentrated) were determined largely by future industrial water requirements.

At present, a number of the major reinforcing mains are complete or almost complete, some are being designed, and others are scheduled to undergo study in the near future.

Sections of the Geyer-Wolff report, now slightly more than a year old, are already undergoing restudy. Such restudy is a vital necessity as revised data on population growth and water use and more complete land use maps become available. The report recognizes the need for continuous restudy, and has proposed an extensive program of reanalysis of studies already made as new information becomes available. The city's new electric analyzer will also make it possible to study many problems which, up to now, have been too complex and time-consuming to attempt using conventional methods. The report discussed the types of problems which can be best solved on the machine and outlined an extensive list of problems to be studied.

The general recommendations and suggestions for future studies made in the Geyer-Wolff report, if followed diligently and imaginatively, should make it possible for Baltimore to develop a first class distribution system at minimum cost.

Summary and Conclusions

In forecasting future water requirements, the following points should be kept in mind:

1. The characteristics of industrial water use differ from from those of domestic use in several major respects and the two should therefore be segregated. Because of these major differences between industrial and domestic consumption, the practice of reporting per capita water consumption data while including industrial water use should be discouraged.

2. Strengthening the distribution system by building portions of ultimate size mains is more economical, more flexible, and causes less inconvenience to other municipal services than does strengthening the system by building all of a smaller diameter main to serve an intermediate design year.

3. Nearly all the industrial consumption in a community is taken by a relatively small number of users; therefore accurate information about total industrial consumption, maximum consumption rates, and location of load points on the distribution system is ordinarily not difficult to obtain.

4. Projecting future industrial consumption in new or undeveloped areas is difficult because there is little reliable information about the land area requirements for various types of industries; neither are there consistent data available on the amount of water used per unit of product.

5. Projecting future industrial consumption in older, already well developed industrial areas is facilitated if the ultimate consumption in the area is planned for and all land possible is to be used.

6. The maximum hour to average day ratio is much lower for industrial water use than for domestic water use in suburban areas. This difference has far reaching implications in the design of distribution mains, pumping plants, and reservoirs, which, in turn, affect the manner of determining water use charges.

7. Information obtained so far about industrial water use indicates that the maximum hour to average day consumption ratio is increasing very slowly.

8. New developments in the analysis and operation of distribution systems such as the electric network analyzer and improved remote control and recording instruments suggest that every municipal water system should have a permanent engineering and planning department engaged in planning future improvements to the system as well as working out more economical day-to-day operating programs. The requirements of industrial water users will have a considerable effect on the work of such a department.

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Flocculation and Flocculation Aids

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A paper presented on Sep. 13, 1956, at the Michigan Section Meeting, Kalamazoo, Mich., by Herbert E. Hudson Jr., Assoc., Hazen & Sawyer, Engrs., Detroit, Mich.

FLOCCULATION is a process of bringing together separate particles into groups of particles. The process is usually carried on by the use of electrical, mechanical, or chemical forces, or combinations of them. In water treatment, flocculation is used to consolidate the many fine particles of suspended material occurring in water into relatively large masses. The process usually employs a coagulant which is ordinarily a salt of aluminum or iron. This reacts with water to form hydrous oxides of a sticky, gelatinous nature which serve to bind together the separate particles.

Water purification has progressed a long way from the time when the coagulation basin was a "mixed-up" chamber to whose inlet alum was added and in which flocculation happened in a leisurely fashion and sedimentation took place as best it could (*1*). Today, flocculation is only part of the coagulation process which includes: [1] addition of coagulating or flocculating materials; [2] their dispersion throughout the fluid; [3] agitation to bring the particles in contact with the coagulating agents and with each other; and [4] agitation to consolidate the growing particles into agglomerates of suitable size and density. The last two agitation phases may be termed flocculation.

Sedimentation is another process whose requirements compel it to be separate from flocculation. Filtration, once the sole treatment, is now the last line of a defense in depth against disease. Thus, flocculation is one link in the chain of methods required to produce uniformly high-quality water at minimum cost. The effectiveness of each of these processes affects the behavior of each of the others.

At about the time flocculation was gaining recognition as a distinct part of the treatment process, Baylis (*2*) discovered the value of acid-treated sodium silicate as a flocculation aid. A large variety of silica aids has since developed. More recently publicized are the organic polyelectrolytes, which aid the coagulant in binding together the discrete particles naturally present in the water.

Flocculation has a number of missions. If it is to aid in removing coarse suspended material, colloidal material, microscopic organisms and the even smaller bacteria and viruses, the process must enmesh in the flocculant particles, nearly 100 per cent of all of the suspended material in the water. In addition, the flocculant precipitates have the power of adsorbing some dissolved materials from water, such as those that produce tastes and odors or reduce chlorine; flocculation should be expected to aid in the removal of these materials.

The great majority of the floc particles should be built into sufficiently

large masses to settle rapidly in order to relieve the filters of as much load as possible. The floc particles should also be dense to aid rapid settlement. Floc must also be sturdy enough to resist any agitation encountered so that it will not be broken up prior to sedimentation and so that it will not break up during removal in the filter media. Floc must be large, tough and dense.

Equipment

The early flocculating equipment was of the baffled type, in which the water was forced to follow a tortuous path for a period of as much as half an hour. Such chambers were usually designed for nominal velocities of approximately 1 fps. In this classification may be included pipelines and conduits that are used for flocculation. Good flocculation may be attained by such conduits, even when straight, if the degree of agitation in them (caused by boundary friction and bends) is of the right magnitude. All of the units that rely purely on conduits or baffling for flocculation are subject to the limitation that they function best at one particular rate of flow; below this rate, the agitation is insufficient, and above it, excessive.

Mechanical flocculating basins have been in use for more than 30 years, the oldest type built with vertical shafts to which paddles were attached (*3*). A little over 20 years ago, there came into fairly widespread use, the horizontal-shaft flocculators in which a number of paddles were fixed to a shaft which was located transverse to the direction of flow. These units were usually constructed in existing settling basins, but proved so effective that they were subsequently widely used in new plants. A development that followed shortly after the original transverse-shaft unit, involved shafts parallel to the direction of flow. Some of these units were compartmented into a series of cells, and others were kept completely or partially open in order to encourage the recycling of solids back to the beginning of the process.

A few flocculating chambers using diffused compressed air have been built. More recently there have been developed flocculating units involving pump impeller type agitators which circulate the water with one impeller in each compartment. Experience with these units is still somewhat limited. Walking beam units have performed very effectively in a number of installations.

The trend in recent years has been to incorporate the flocculating equipment and the settling basin into a single chamber. This is done both for reasons of economy and because this arrangement permits an efficient discharge of flocculated water from the flocculator outlet into the settling basins without undue velocities. For this purpose, submerged weirs, hanging baffles, or permeable baffles are used. The former two methods do not distribute the water throughout the full effective depth of the settling basin, but the permeable baffle inlet does.

Hydraulic Characteristics

Many studies have been made of the hydraulic characteristics of conventional mixing and flocculating chambers. It has long been recognized that, unless carefully controlled, water flowing through a mixing chamber will short-circuit, much of it escaping in far less than the theoretical detention time. There is a limit to what can be done to prevent short-circuiting in a mixing basin. The flow pattern

is never tranquil; mixing is an essential part of the process, so some of the water will escape quickly from the basin. This problem is often solved by constructing the chamber as a series of compartments, each one of which may short-circuit to some extent, but with the series setup damping the short-circuiting materially. Generally, not less than 3 compartments will be desirable and 4 or more preferable. A single compartment containing good mixing equipment will allow the escape of 40 per cent of the input in half the nominal detention time. A series of three such units, however, allows the escape of only 19 per cent of the water in half the detention time (*4*).

Of even more importance are the horizontal flow-through characteristics of the settling basin. It is possible, by good design, to approach much closer to the theoretical detention time than one can with a mixing chamber, because little mixing takes place in a well designed settling basin. Prevention of mixing requires careful design of inlet and outlet structures as well as careful proportioning of the length, width and depth in order to attain stable flow patterns, to prevent scour, and to attain good removal.

The solids-contact reactor differs from conventional pretreatment units in that it deliberately uses vertical flows in the production of floc and in separating floc from the water. Most solids-contact units are circular or square in plan, and have a central mixing and flocculating zone surrounded by a clarification zone. Floc is separated from the water in an area where water rises to skimming outlet weirs. Some of the reactors are rectangular and discharge bilaterally rather than radially to the outlet zone. In general, the flow is downward in the flocculating zone and upward in the zone of separation. It is important to keep in mind that the solids-contact unit performs the same functions as the conventional unit—flocculation followed by clarification.

An important difference in design between conventional units and solids-contact reactors involves the overflow rate (usually expressed in gallons per day per square foot). For clarification, without softening, loadings of 1,000–2,000 gpd per square foot may be used with the solids contact reactors, and loadings of 300 to 1,000 gpd per square foot are more common in the conventional units.

The solids-contact reactor does a good job at relatively high loading because of the nature of the floc produced. It is expected that a solids contact reactor will produce floc that will settle at 1.5 in. per minute, and conventional flocculation aims to produce floc that will settle at only 0.8 in. per minute.

Usually the solids-contact reactor has only one flocculating compartment, and, with good mixing, short-circuiting should be expected to be considerable. The short-circuiting is even further encouraged by the recycling of slurry from the clarification zone back to the flocculation zone in certain units. The disadvantages of these apparently unsatisfactory hydraulic characteristics are more than offset by other forces involved in the mechanism of coagulation.

Mechanism

There is an extensive literature on the mechanism of coagulation (*5*). This mechanism involves the charge on the colloidal particles, and its neutralization by the flocculating agent. Langelier and his colleagues (*6*) main-

tain that unsatisfactory coagulation results from the presence of too little negatively charged colloidal material, and that improved coagulation may be obtained by adding colloids such as activated silica, bentonite, or other negatively charged materials. The additional particles of these flocculation aids are held to promote the agglomeration of all the suspended particles present. Langelier (*7*) expresses the summation of the charges on particles suspended in the water in terms of the exchange capacity of the solids. Others explain flocculation on the basis of hydrogen bonding (*8*).

Present day thinking on flocculation is founded on the ideas of Smoluchowski (*9*). These are well summarized in recent publications (*4, 10*). On the basis of his work, Camp and Stein demonstrated that the rate of flocculation is directly dependent on the velocity gradient (G) in the flocculating chamber (*11*). The velocity gradient is the rate of change of velocity in a fluid per unit distance. If we consider the Camp-Stein equation as defining the rate of flocculation with respect to time (T), it follows that the flocculation accomplished will be proportional to the product of the velocity gradient and time. Practical experience in the water purification field has indicated that this product (GT) should be not less than 10,000 nor more than 100,000 (*10, 12*). The mathematics as a whole is less simple than this makes it sound, for DallaValle (*13*) has shown that the number of particles available for flocculation declines as flocculation continues.

The velocity gradient is given in the units of velocity per unit distance, as, for example, feet per second per foot. Using consistent units and expressing detention time in seconds, very gentle agitation ($G = 4$ fps per foot) and a detention time of 20 min give a GT value of 4,800. Such a value has usually been found to be insufficient, and a detention period of not less than 40 min at low agitating rates would be necessary. On the other hand, with vigorous agitation ($G = 25$ fps per foot) and a detention time of 30 min, a value for GT of 45,000 is obtained.

Very few plants have values for G as low as 4 designed into them. In a few cases, such values may occur in the inlet zones of the settling basins as a result of inlet turbulence. Values for G of the order of 10–15 seem most common in mechanical flocculating chambers, and it is clear that values of G above 40 tend to produce water that is thoroughly flocculated, but in which the settling velocity of the floc is relatively low.

Many of the early studies on flocculation placed great emphasis on the isoelectric point, which is that chemical balance point (reached as coagulant dosage is increased) at which the most rapid floc formation and most complete removal takes place. A certain amount of alkalinity is required for reaction with each unit of coagulant added, so that alkalinity is "used up" in the process of coagulation. If the raw water does not contain enough to enable flocculation at the isoelectric point, more alkalinity must be supplied to enable the process to function efficiently. The isoelectric point is readily determined through jar tests. Frequently, less coagulant is used than the jar tests indicate as the amount necessary to reach the isoelectric point, because the improvement achieved by going to the point of maximum efficiency is sometimes considered insufficient to justify the cost.

Camp and Stein have also shown that the rate of floc formation is directly proportional to the concentra-

tion of particles present. In addition, the larger particles present in the water are important as nuclei for floc formation and as weighting agents, to make the floc heavier. This is particularly well demonstrated in solids contact reactors, in which excellent flocculation frequently takes place in comparatively brief flocculating times. The fast-settling floc produced may indicate that flocculation is taking place at low velocity gradients in the slurry pool or sludge blanket. Some of the solids contact reactors are designed to recycle completed floc particles into the raw water, so that the flocculation process may be carried on in the presence of a matrix of existing floc. Though such a process automatically short-circuits the flocculating chamber by increasing the total rate of throughput, the net result is a very high-quality water produced in a relatively short time (*14*).

Jar Tests

The laboratory stirring machine is a familiar device in most water treatment laboratories. Usually it consists of a set of adjacent paddles, each of which agitates the water in a different container. The containers are ordinarily 1- or 2-liter beakers. An equal portion of raw water is placed in each beaker and a different coagulant dose applied to each. After a standardized period of stirring, the floc is inspected and its size and appearance observed. The rate of sedimentation of the floc may also be observed and may be an important factor in deciding which coagulant dose is the more efficient. Parallel experiments may also be run on flocculation aids.

Visual inspection of the beakers after a stirring-machine test can often be misleading. Under one set of conditions, bulky looking floc particles which look as though they will yield excellent results may be formed. Under another set of conditions (such as a high stirring speed), very small floc particles, which may not look nearly as satisfactory as the larger ones may be obtained. Determination of the concentration of sediment remaining after settling in the beakers may reveal, however, that the small floc produced clear, settled water. This occurred during jar tests at the Springwells filtration plant in Detroit to determine the most effective stirring speed for flocculation (*15*). At a given long flocculation time, low stirring speeds produced good-looking floc, and high stirring speeds produced what appeared to be "pin-point" floc. Surprisingly, the latter produced a lower settled water turbidity than the former. Apparently, the flocculation time at low speeds ($G = 4$) was too short to entrap all the suspended material, and, at higher speeds ($G = 17$–40), the flocculation was complete.

Coagulant Aids

Coagulant aids are used for two distinctly different purposes—to increase the strength of the floc and to make the floc settle more rapidly. Clays, lime, and pulverized limestone are used primarily to increase settling rates. For increasing floc strength, there is now available a wide variety of aids of two general types: the silicates, and the more recently publicized organic coagulant aids.

The necessity for improving sedimentation occurs most commonly when raw waters are relatively clear. These are frequently times during which the waters contain unusually high concentrations of microscopic organisms. Where iron coagulants are in use or can be used, partial softening by the use of lime helps to produce

rapidly settling precipitates which carry down high proportions of the microorganisms that might otherwise settle very slowly. Pulverized limestone is a relatively inert floc-weighting agent. Certain of the modern high-rate filtration plants need the use of floc-weighting agents to improve sedimentation sufficiently during periods of high microscopic counts. Without the use of the floc-weighting agents, filter runs become too short for practical operation.

Clay has long been used for increasing the weight of floc to improve sedimentation. Clays are not always completely inert however, and they sometimes strengthen the floc at the same time that they make it settle more rapidly. This appears particularly true of the bentonites, which are reported to have considerable adsorptive capacity and may enter into the complex reactions of flocculation in more than a mechanical way. There is clear evidence that the use of the clays, and particularly bentonite, aids greatly in reducing the load applied to the filters.

On the other hand, the floc-strengthening agents add materially to the power with which the floc binds the sediment particles in the water. These agents usually improve the rate of sedimentation, but their use is often accompanied by shortened filter runs resulting from the increase in floc strength which they produce. This is especially true of the activated silica materials. No specific recommendation for the best type of silica can be made; this must be determined by trial. Jar tests are especially valuable for observing the relative efficiency of the various silica materials.

The activated silica materials are sometimes cranky to prepare and a tank full of gummy sol may result if the neutralization is not properly handled. Continuous-flow silica activators are available. These use various types of neutralizing or activating agents, including acid, chlorine, alum, ammonium and other salts.

The special value of the activated silicas is in strengthening floc at times of the year when it is extremely difficult to obtain good flocculation. For example, on Great Lakes waters, the greatest difficulty in obtaining floc of satisfactory strength appears to occur after storms which have raised the raw-water turbidity to a high value. During the period of declining turbidity, following the maximum value, weak flocculation may persist for several days to several months. The symptoms of the difficulty are unusually poor sedimentation and the appearance of flocculated turbidity in the filtered water. This floc turbidity usually does not pass through the sand beds during the early part of the filter runs, but appears toward the ends of the runs when head losses approach the maximum value. Studies on Lake Michigan water have shown that the use of activated silica at such times increases the floc strength approximately sixfold, so that the hazard of penetration of flocculated turbidity (and disease-producing organisms) through the filters is very much reduced.

Another use for the activated silica materials is in high-rate water treatment plants where it is especially important to obtain dense, tough floc. The use of activated silica materials in such plants enables substantial increases in capacity, especially during periods of weak flocculation.

Since World War II, a good deal of information has been issued on the new organic flocculation aids (*16, 17*). The evidence available indicates that they produce substantially the same

results as the activated silica materials. The organic flocculation aids are easily handled. Some of the organic coagulant aids are admixed with bentonite. For these, it is claimed that the organic material and the bentonite appear to be mutually helpful. They cost from $0.50 to $1.50 per pound, but, as with the silica materials, dosages of only a few parts per million are required to aid in obtaining good flocculation.

With some of the new organic floc coagulant aids, there are still toxicity questions, and some aids that have been established as very valuable in industrial water and waste treatment are not yet being advocated for municipal water supply use. Extensive toxicity testing has been done and is being continued to ascertain whether or not the materials may safely be used in the production of drinking water. Studies have not advanced to the degree that unqualified approval of their use for the purification of public water supplies can yet be given.

It does not seem likely that any water filtration plant should need to use the coagulant aids at all times. Their use might properly be seasonal, and should be instituted to protect the public health during periods when ordinary flocculation procedures are not fully effective. The national office of the AWWA is energetically assembling information on these new coagulant aids and on their safety for use in municipal water supply works.

Effectiveness

The effectiveness of the flocculation process is measured by the behavior of the settling basins and the behavior of the filters. Twenty-five years ago it was expected that, using flocculation through baffled mixing chambers, settling basins would reduce raw water turbidity to a value of 5–10 ppm. The subsequent development of mechanical flocculating chambers, together with the improvements yielded by flash mixing and flocculation aids, have brought about the situation under which it should now be expected to achieve a settled water turbidity of not more than 3 ppm. Settled water turbidities averaging 2, and occasional values as low as 0.3 ppm are attained in many of the more recently built plants. The clarity of the settled water is therefore a good indicator of the effectiveness of the flocculation.

The author has had the opportunity of comparing the operating results from a number of modern rapid sand filtration plants, some of which had flocculating facilities giving a minimum of 30 min detention time with agitation velocities of 1–2 fps; others had much shorter flocculating periods and lower agitation velocities. The plants with more complete flocculating facilities sent less than half as much sediment to the filters as did those plants with less extensive flocculating facilities. All of these plants were producing high-grade filtered water. The conclusion that flocculation is a critical element in relieving the load applied to the filters cannot be evaded. Against the contention that it may not be necessary to reduce the load applied to the filters, it should be pointed out that, for comparable applied-water loadings, plants with good flocculating facilities require considerably less coagulant than those with less adequate facilities.

A measure of the effectiveness of flocculation is found in the behavior of the filter beds. This may be manifested either through the clogging rate of the filter or through the clarity of the filtered effluent. Both factors are

important. In all that follows, it is assumed that the filter beds are kept in good condition. Fouled filters fail to fulfill their function.

Short filter runs may be caused by either of two things: unusually tough floc or insufficient removal of solids by the settling basins. Sharply curved loss-of-head graphs, indicating a small clogging rate at the beginning of the run and a rapidly increasing clogging rate toward the end of the run, indicate low penetration of floc into the bed. Such behavior is usually accompanied by filter effluents free of coagulated turbidity. This occurs when the floc is strong (*18*).

Long filter runs accompanied by clear effluents indicate good behavior of pretreatment facilities; long runs accompanied by turbid effluents may indicate unsatisfactory pretreatment. In general, a small but uniform rate of increase of loss of head through the filter indicates a continuing penetration of floc into the filter bed, caused by weak flocculation. Toward the end of the run, this may be followed by break-through of coagulated turbidity into the filter effluents.

Turbidity in the effluent may result from insufficient coagulant, insufficient flocculation, or weak flocculation. When the concentration of coagulant or the flocculating process is insufficient to entrap in the floc all of the fine sediment particles, unflocculated colloidal material may appear in the filter influent and may pass through the filter. Most filtered water turbidimeters such as the Baylis or St. Louis instruments will register this colloidal turbidity. They will not accurately indicate the concentration of flocculated turbidity passing through the filters since this material is usually very high in water content and does not impede the transmission of light in the optical turbidimetric determination. Flocculated turbidity may be seen by reflected light, as in the Baylis floc detector, or in a clear well illuminated by side lighting. The cotton plug filter also reveals the presence of flocculated turbidity. Presumably it does not impede the passage of colloidal material (*19*).

The distinction between colloidal and flocculent material in the effluent is important, for this distinction tells whether the unsatisfactory effluent is caused by insufficient flocculation or weakly bound floc. The remedy is different for each of these ailments.

Conclusion

In order to meet certain situations, the operator should first classify them by the behavior of the filter units. If the filter effluent is turbid, it is essential to find out whether the turbidity is flocculated or colloidal. If colloidal, the coagulant dose may be incorrect. Jar tests will help. Either too much or too little coagulant, or insufficient alkalinity in the water may cause the presence of colloidal turbidity in the water. Running the flocculating equipment too slowly may produce a similar effect. Speeding up the flocculators may aid in the entrapment of the colloidal particles in the floc.

If the filtered water contains flocculated turbidity, it will help little to increase the speed of agitation, because this will tend to break up the floc more than ever. This, a flocculating aid should be of help, and possibly, a reduction in flocculator speed will aid. Washing the filters at a lower terminal head loss would probably be of considerable assistance.

When short filter runs confront the plant operator, the use of clays, ben-

tonite, lime-and-iron treatment, or pulverized limestone may be of aid in reducing the load applied to the filters. Occasionally, coagulant aids improve the sedimentation so greatly as to overbalance the effect of toughening they give to the floc, but coagulant aids in short-run periods may make the runs even shorter. If the filter runs are long and the water is clear, operation is satisfactory.

If none of the above operating suggestions is effective, there is a good possibility that improved plant facilities are required. This improved construction would apply particularly to the chemical treatment, flocculating, and settling facilities. Design knowledge is available for correcting almost any clarification problem a filtration plant operator may encounter.

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Western Slope Water Development for Denver

Earl L. Mosley

A paper presented on Nov. 27, 1956, at the Rocky Mountain Section Meeting, Colorado Springs, Colo., by Earl L. Mosley, Project Engr., Denver Board of Water Commissioners, Denver, Colo.

PUBLIC officials of Denver have recognized in past years that water obtained from the original source (the South Platte River), while sufficient for initial growth, would never be enough to sustain the metropolis that would sooner or later come into being.

Consequently, studies looking toward the development of water from various tributaries of the Colorado River were begun even before the purchase by the city of the Denver water plant and system on Nov. 1, 1918.

Past Plans and Projects

In July 1915, the Public Utilities Commission of the city and county of Denver entered into an agreement with the Van Sant-Houghton Company, engineers and contractors of San Francisco, Calif., to:

> complete the engineering work and do any and all things necessary and incident to the preparation of plans, specifications, and estimates for a complete and adequate system of water works for the City and County of Denver, carried to such a state of completion that the utilities commission will be enabled to proceed with advertisement for proposals for contracts for the construction of such system.

On Feb. 21, 1916, an option agreement was executed between The Denver Union Water Company and the city and county of Denver granting to the city an option to purchase the property of the company embraced in the rating base fixed by a special master's report.

As a result of this action, the original agreement with the Van Sant-Houghton organization was modified by, among other things, deferring the preparation of detailed specifications until after a decision had been reached by a vote of the people on the proposed purchase of the existing water plant and system.

The modified agreement of Sep. 15, 1916, resulted in the submission of a report (*1*) in December 1916 which was geared to the possible purchase of the existing plant and its future expansion.

Among the recommendations made was one suggesting the development of a supply from the Western Slope of the Continental Divide, naming the Fraser, the Williams Fork, and the Blue rivers as possible sources for future attention (Fig. 1).

When the existing plant was placed under the management and control of the city acting by and through its Board of Water Commissioners, it was evident that certain major improvements should be made as soon as possible, and a bond issue in the amount of $5,000,000 was proposed for that purpose. This bond issue was voted down on May 17, 1921, leaving the city in a perilous condition, both as to its immediate need of improved fire protection and the possibility of

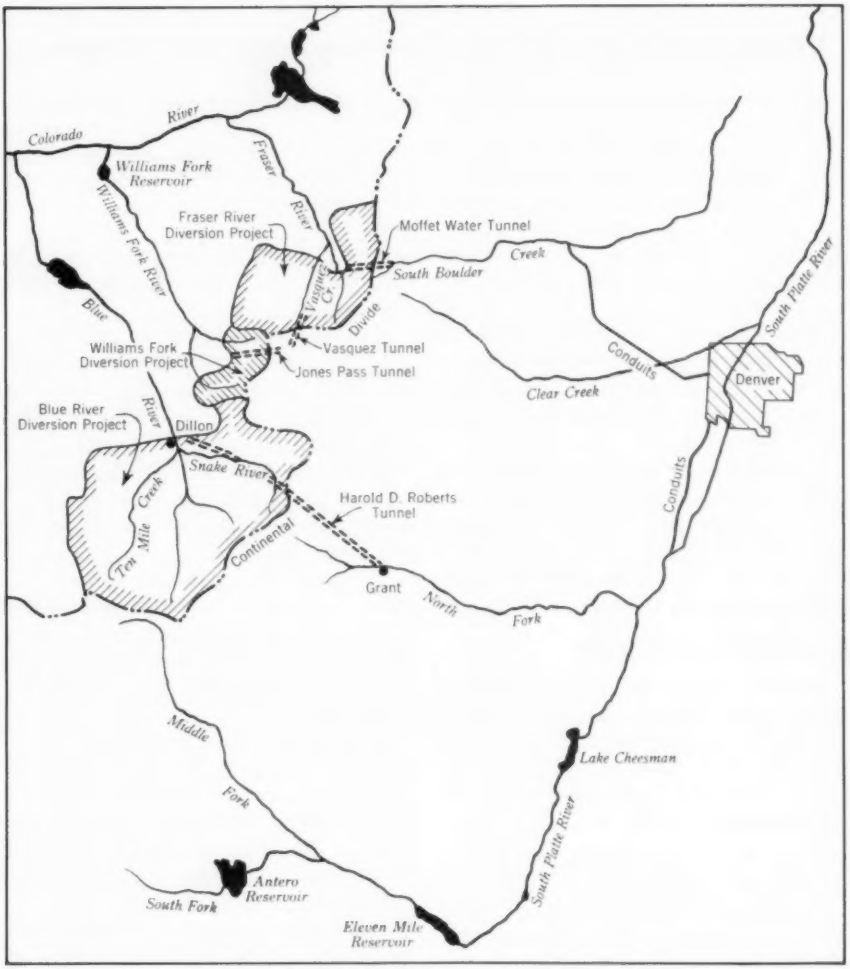

Fig. 1. Water Sources for Denver

the failure of its supply of water for domestic purposes. It was also left with no well defined policy as to the future development of the system.

Realizing the vital importance to the citizens of a complete understanding of the existing conditions, the Denver Civic and Commercial Association took steps to place the facts before them. The association appointed from its members a committee of prominent local engineers with instructions that they should nominate, for the consideration of the Board of Water Commissioners of the city and county of Denver, one or more engineers competent both to pass upon and to supplement the existing data and to make

practical recommendations for the future.

The board adopted the recommendation of the association and promptly appointed a Board of Engineering Review which was instructed to investigate the present condition in addition to the future needs of the distribution system, and to consider the total available water supply, while taking into account the city's rapidly increasing population.

It was, after careful study, decided to prepare a comprehensive program for the future which could be accepted by the citizens of Denver as a basis for future economic expenditure.

Selected as members of the Board of Review were Harry T. Cory, Herbert S. Crocker and Dabney H. Maury, all well known engineers in their respective fields. This board began its work in February 1922 and submitted its report on Aug. 15 of that year (*2*).

The conclusions and recommendations were eleven in number. Number 8, still of interest today, reads:

> It would be a very short-sighted policy to limit the growth of Denver by failing to provide a sufficient water supply for the future. The supply available from the Eastern Slope is inadequate for the future Denver. Provisions should be made at once to secure a perpetual right to all possible diversion from the Western Slope. It is conservatively estimated that 250,000 acre-ft may be obtained from that source.

The present construction program when completed in 1962 will, it is estimated, enable the Denver Water Department to divert in an average year about 268,000 acre-ft from the Fraser, Williams, and Blue rivers.

By the 1955 federal court stipulation and decree (*3*), all water diverted from these sources must be confined to municipal use only. No diversions can be made for agricultural use.

One of the most interesting of all of the many charts and diagrams in the Board of Review's report is the 80-year population forecast for Denver (1922–2002). Comments on this chart in the report conclude with the statement that: "The final conclusion of the matter is that it is conservative to predict that Denver will reach the million mark in 80 years, a more probable time is 70 years, and an optimistic time is 60 years."

Revised estimates of population prepared by outside authorities (*4*) in 1955 predict a population in the Denver metropolitan area of 1,000,000 by 1980, increasing to 1,320,000 by the year 2000. It is to be noted that the forecast of 1,000,000 by 1980 is almost identical with the 1922 Board of Review's optimistic prediction of 1,000,000 people by 1982.

Two years prior to the Board of Review report, George M. Bull was employed by the Board of Water Commissioners as a consulting engineer dealing with the requistion of water rights on the Western Slope. He began field work on Fraser River rights on Jul. 4, 1921, while work was also being done that same summer on the Williams Fork portion of the system. Denver's decreed rights to direct flow on both of these streams are dated Jul. 4, 1921.

In 1922 Bull made preliminary surveys for filing purposes on the Blue River and its tributaries.

In July 1926 the board authorized surveys to be made for the purpose of determining the most feasible project for the development of Western Slope water from the Blue River to the South Platte Valley. In his report trans-

mitted to the board on May 1, 1927, Bull reviewed the work done preliminary to the making of filings on the Fraser, Williams Fork and Blue rivers. He also stated that these filings were made at an elevation which allowed for the construction of the Moffat Tunnel, with the Williams Fork Diversion at about the same elevation as previous filings made by the Transmountain Water Company, and the Blue River Diversion at el 10,300 as previously recommended by J. B. Lippencott.

The filings made for the Fraser and Williams Fork diversions were stated by Bull to be the proper ones. However, he disagreed with the 1914 Lippencott plan to construct some 65 miles of collecting canals feeding into a tunnel with its western portal at el 10,300 for the Blue River Project, stating that the cost would be excessive and operation very questionable from a standpoint of both economy and efficiency.

Fig. 2. Fraser River Collection Siphon

Second of two 84 in.-diameter siphons under construction.

For this particular diversion project, Bull considered the following alternate proposals:

1. Providing for maximum diversion from the Blue, the Ten Mile and the Snake at Dillon with a tunnel having its west portal at el 8,842, eliminating all intercepting canals. This tunnel was to be about 23 miles long

and have a carrying capacity of 1,600 fps, with a gross annual summer water supply of about 242,000 acre-ft.

2. A project with the intake of a transmountain tunnel at el 9,112. The intake under this plan was to be on the Blue River about 4 miles upstream from Dillon and 1 mile below the mouth of Swan Creek. This alternative project consisted of a transmountain tunnel approximately 19 miles long with a canal system running to the west to intercept Ten Mile Creek about 1 mile above Frisco, and a diversion canal to the north and east intercepting the Snake at the junction of the north and south forks of the Snake about 2½ miles above Keystone. From this project the estimated total gross annual summer water supply was approximately 218,000 acre-ft.

3. The west portal of the third alternative project was to be located on the Swan River about 3½ miles above the junction of the Swan with the Blue River at el 9,500. The plan called for a diversion canal running to the west and south to intercept Blue River proper a short distance below Breckenridge, Colo. An extension of this canal including a 4-mile tunnel through the Ten Mile Range would intercept the Ten Mile River at a point about ½ mile below Wheeler. In addition to this, the Snake River water would be intercepted by a canal running north from the west portal of the 13 mile transcontinental tunnel to a point about 1 mile above the junction of the north and south forks of that stream. This canal would also intercept the waters of the Swan. From the entire project the total estimated divertible summer supply was estimated to be approximately 183,000 acre-ft.

Without going further into the history of these west slope engineering studies and the legal problems presented by them, it is enough to note that the final plans adopted on the Fraser and Williams Fork units were those accepted as proper by Bull in his 1927 report. Today, the Blue River unit under construction generally follows Plan 1 as outlined by him at that time. It is of interest to note that the flow line elevation of the west portal of the Harold D. Roberts Tunnel now under construction is less than 3 ft higher than the 8,842 figure selected by Bull about 30 years ago.

Although planning and preliminary work of an engineering and legal nature was carried on continuously during the 15 years following the purchase of the water system in 1918, no projects were actually put under construction for the purpose of diverting Western Slope water into the Denver municipal system in that time.

The drought of the early 1930's created an immediate necessity for supplementing the South Platte River supply. This emergency condition, coupled with the existence of the pioneer bore driven under the Continental Divide in connection with the Moffat Railroad Tunnel, brought about actual construction work on the first stages of both the Fraser and Williams Fork units. As a result, water became available for use in Denver from the Fraser River via the Moffat Water Tunnel in June 1936 and by exchange from the Williams Fork River via the Jones Pass Tunnel in the spring of 1940. First year diversions from these sources totalled 12,252 and 9,516 acre-ft respectively.

Closed extensions to the Fraser River open canal system, made subsequent to the original construction and completed in 1936, permitted the diversion of three times the original volume

of water brought to the Eastern Slope in 1955, the total being 37,276 acre-ft for that year.

The 1955 yield from the headwaters of the Williams Fork River delivered at the east portal of the Jones Pass transcontinental tunnel totaled 10,534 acre-ft, all collected by the original closed conduit system to which no extensions have been made to date. The total west slope diversions made into the Denver system in the year 1955 was the sum of these two amounts, 47,810 acre-ft.

the past 10 years has been about 4.4 per cent, with a per capita increase in consumption in that same time averaging 6.6 per cent. In other words, the demand for filtered water is now increasing at a rate one and one-half times the population rate.

The Denver Board of Water Commissioners met this challenge by asking for and obtaining, by vote of its citizens, two bond issues to finance planned additions and betterments to the city plant. The first of these issues was approved in May 1947 in the amount of

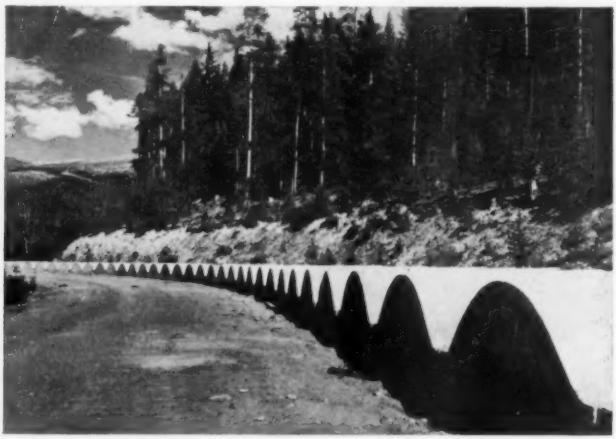

Fig. 3. Precast Concrete Cover on Concrete-Lined Canal

Recent Developments

The leveling-off process predicted by most economists after the end of World War II did not materialize. On the contrary, the accelerated demand for municipal water by reason of population increases, combined with a rising per capita use, has presented real problems to water works management throughout most of the western states. This condition has been particularly evident in the Denver area, where the average annual population increase for

$23,000,000, which was used, together with net operating revenues and other available funds, to increase the supply of filtered water by about 25 per cent.

By the end of 1955 a total of $41,721,000 had been spent for capital improvements under the 1947 expansion program.

The second bond issue of $75,000,000 was approved at a special election held on Aug. 9, 1955. It is the nucleus of a 15-year, $101,000,000 construction program for still further plant expansion. Fifty-seven per cent of this total

expenditure is allocated to projects directly designed to increase transmountain water diversions from tributaries of the Colorado River. It is estimated that, when completed 6 years hence, diversions from the Western Slope for Denver municipal use will be available when needed in an average annual amount of 220,000 acre-ft over and above the total volume of water diverted in 1955.

At an annual rate of 1 acre-ft of water for each family of four, this volume of water will adequately meet the needs of 880,000 people in addition to the 650,000 currently served by the Denver system.

The program now under way, with a total of approximately $58,000,000 of construction work, including materials and engineering already under contract, and provides for additional facilities, as far as transmountain diversions are concerned. These diversions are all of Colorado River tributaries—the Blue, Williams Fork, and Fraser rivers.

Fraser River Project

All of the work to be done under the present program, in connection with the rehabilitation and enlargement of the Fraser collection system which feeds the west portal of the Moffat Water Tunnel, is now under contract and completion is expected in time for the 1958 spring runoff. In general the maximum carrying capacity of the main stem of the open canal in this system is being increased from 300 to 650 fps. To accomplish the desired result it has been found necessary to add a second steel barrel, 84 in. in diameter, to two siphons having a total length of 4,022 ft (Fig. 2) ; to line with gunite a tunnel 2,184 ft long; to repair the concrete lining and to cover a section of the original canal for a length of about 4½ miles; and to provide emergency waste-ways together with all of the valves and other appurtenances required to permit 12-month operation of a closed conduit located in mountainous terrain at elevations ranging from 9,100 to 10,000 ft above sea level.

The problem of covering the existing open concrete-lined canal while in service was perhaps the most unusual requirement in all of the plans used for any one of this group of projects.

Bids were taken on an optional basis, with prospective bidders permitted to submit their own designs deviating from the conventional flat slab design shown on the plans, with the proviso that any alternate design should be at least equal in all respects to the details shown on the drawings, and further, that such alternate designs must be submitted for the written approval of the engineer before they would be considered as acceptable for bidding.

The alternate design chosen was a precast, curved slab varying in length from 14 ft to 23 ft, 8 in. in length (Fig. 3). The entire slab is 3½ in. thick with appropriate bar reinforcing and precast bulkheads at each end resting on a carefully prepared sand cushion placed on top of the upper edge of the concrete canal lining. Alfred J. Ryan of Denver was the consulting engineer employed by the board to prepare the plans and specifications for this work. The Crocker Construction Company of Denver was the contractor, with field supervision given by members of the board's engineering staff.

The increase in carrying capacity at this time was made necessary so that the water to be brought into the Fraser system from the Williams Fork watershed in 1958 could be handled when needed during peak periods in addition

to water of the St. Louis Creek extension which became available for the first time in the spring of 1956.

When the program for this area is completed early in 1958, the estimated average annual yield of water available at the west portal of the Moffat Water Tunnel will be 82,700 acre-ft, with 14,700 acre-ft of that total dependent upon the enlargement of the Williams Fork Reservoir.

As the combined flow of the entire Fraser and Williams Fork diversion projects will be available at the west portal of the Moffat Water Tunnel in early summer 1958, it will be necessary to increase the carrying capacity of this 6.3-mile underground structure by that time. This will be accomplished by completing the concrete lining of the east $2\frac{1}{3}$ miles to a finished $10\frac{1}{2}$-ft diameter. Work now being done on this project is shown in Fig. 4.

The contract work under which this increased capacity will be made possible is to be done during two winter seasons (Nov. 1, 1956 to Apr. 1, 1957, and Nov. 1, 1957 to Apr. 1, 1958). As scheduled, there will be no interference with the flow of water through the tunnel during summer 1957.

When completed, the estimated maximum carrying capacity will be raised from 600 to about 1,300 fps, thus enabling the board to utilize its full decreed carrying capacity of 1,280 fps.

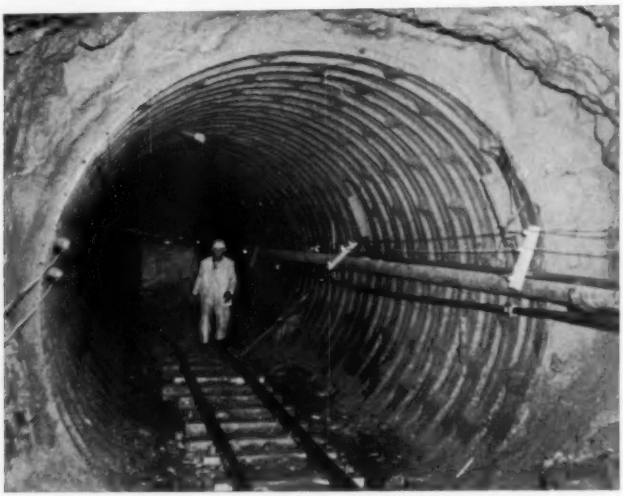

Fig. 4. Moffat Tunnel Enlargement

Steel liners are shown in place.

Williams Fork Project

Another important project is the Williams Fork River project which includes the direct diversion of the head waters of this Colorado River tributary through the existing Jones Pass Tunnel to the Eastern Slope, and the enlargement of the Williams Fork reservoir near the mouth of the river not far from Parshall, Colo.

Water has been diverted from the upper watershed of the Williams Fork

River through the Jones Pass Tunnel to the west fork of Clear Creek since 1940 when the first stage of the collection system and the tunnel were completed with a Public Works Administration grant by the city of Denver. Since that time, water diverted by this system to the Eastern Slope has flowed down Clear Creek in amounts varying from 1,700 to 11,200 acre-ft annually. Although none of this water has been used directly in the city's system, its delivery to Clear Creek and thence to the South Platte River has made possible the exchange of a portion of the equivalent flow at the city's intake on the South Platte or into Lake Cheesman for storage as circumstances at the moment dictated. Limitations and the erratic nature of exchange opportunities cause a loss to the city of a considerable portion of the supplies divertible from the present Williams Fork system. Further, because of limitations of channel capacity of Clear Creek, the city has had to forego diverting all of the water available to the present Williams Fork collection system during certain periods of the year.

Correction of this situation will be made on completion in May 1, 1958, of the Vasquez Tunnel Project, which will pick up the Jones Pass Tunnel water at its east portal and convey it under the Continental Divide with discharge into the headwaters of Vasquez Creek, eventually to reach the city through the Fraser River collection system and the Moffat Water Tunnel.

This will commingle the waters of the Williams Fork Diversion system with those of the Fraser collection system before their arrival at the west portal of the Moffat Tunnel.

In addition to the Vasquez Tunnel, the project now under contract includes the completion of the lining in the existing Jones Pass Tunnel and the construction of a reinforced concrete structure connecting the east portal of the Jones Pass Tunnel with the south portal of the Vasquez Tunnel.

This new transcontinental tunnel has a standard 7-ft diameter horseshoe section. It is approximately 18,000 ft long extending from the headwaters of Clear Creek to Vasquez Creek. Its calculated maximum carrying capacity is 500 fps, with a differential in portal elevations of 99.55 ft, the invert elevation of the discharge end being at el 10,210 above sea level.

The work yet to be done on the existing Jones Pass Tunnel in order to bring its carrying capacity up to 500 fps consists of completing the concrete lining to a standard 7-ft diameter horseshoe section. This tunnel is about 15,570 ft in length and will include new lining to be installed for a total of approximately 9,090 ft in isolated sections extending throughout its entire length.

The reinforced concrete outlet structure joining the two tunnels consists of a stilling pool, a gate structure, a Parshall flume, a transition, and a cut-and-cover conduit.

New Dam and Power Plant

The remaining unit in this Williams Fork River series of projects is that known as the Williams Fork Dam and Power Plant. It is located on the Williams Fork approximately 2 miles southwest of Parshall, Grand County, Colo. It is situated at elevations of 7,600 to 7,800 ft above sea level.

The original dam was built with a Public Works Administration grant by the city and county of Denver (not the Board of Water Commissioners) in 1938. In 1941 radial gates were installed in the overflow spillway section

to increase its effective operating capacity to 6,600 acre-ft. The original project has been in continuous operation since its construction, and has been used exclusively as a replacement facility for direct Western Slope diversions.

The program now under way, designed to complete the Fraser River and Williams Fork diversions and to obtain new water from the Blue River, will require a substantial increase in replacement storage capacity. The additional replacement storage is being provided at this site by increasing the storage capacity of the reservoir there from 6,600 to 93,637 acre-ft.

The work of raising the dam, now under way, consists of building a thin arch concrete structure on top of the existing gravity arched dam. The present dam will be truncated for a height of about 22 ft in order to provide the necessary width of foundation to accommodate the new arch portion. The design thickness of the new dam will be 10 ft, with crest width increased to 12 ft by means of corbels and parapets. The arch is 30 ft in thickness on the line of centers at the intersection of the old and new dams. The overall height of the completed structure will be approximately 180 ft.

The power plant to be built in conjunction with this dam is of reinforced concrete construction. It will contain one 3,158-kv ac generator, driven by a 4,250-hp vertical shaft reaction type turbine with necessary auxiliary equipment.

Energy produced at this plant will be transmitted over a 69-kv transmission line a distance of about 2 miles to the US Bureau of Reclamation line of the same voltage between the Green Mountain Power Plant and the Granby Pumping Plant.

Fig. 5. East Portal, Harold D. Roberts Tunnel

It is estimated that the average annual replacement needs supplied from the Williams Fork reservoir, when all of the diversion projects under this program have been completed, will be 14,700 acre-ft for the Fraser, 7,400 acre-ft for the Williams Fork, and 30,800 acre-ft for the Blue River; the total requirement for all three being 52,900 acre-ft.

The remaining unit in the Williams Fork group of projects has to do with a proposed extension of the closed con-

duit collection system supplying the Jones Pass Tunnel. This work is now being designed to allow for starting contracts in the summer of 1958.

This phase includes the construction of nearly 25 miles of steel and concrete pipelines, plus the duplication or replacement in larger sizes of about 3 miles of existing steel pipe to meet changed design requirements. Pipe capacities of the completed gathering system will range from 5 to 400 cfs. The location of these several lines at elevations of more than 10,400 ft in extremely rugged terrain poses a construction problem of no mean proportions.

Blue River Project

The last Western Slope diversion, the Blue River unit, is the largest and most costly of all. It can best be described in three parts: [1] a dam of as yet undetermined size located about 1 mile downstream from Dillon, Colo., on the Blue River; [2] the Harold D. Roberts Tunnel now under construction; and [3] enlargement of the channel of the North Fork of the South Platte River between the east portal of the Roberts Tunnel and its junction with the South Fork at South Platte, Colo.

Engineers are now engaged in the study of the many problems related to a project of the magnitude of this particular, entirely new diversion activity. Although no definite decision has yet been made, it can be said that three possible reservoir capacities are now under review. These are 14,000, 71,000, or 252,678 acre-ft respectively. Because of foundation conditions, the dam in any event will be of the earth-fill type with heights above stream bed of approximately 78 ft, 140 ft, or 233 ft.

The idea of constructing a tunnel under the Continental Divide to convey water from the headwaters of the Colorado River into the South Platte basin at a point upstream of Denver dates back more than 40 years.

A tunnel to convey water from the West Slope to the East Slope through this area has, during the long period it has been under consideration, been referred to variously as the Blue River Tunnel, the Montezuma Tunnel and, since October 1955, as the Harold D. Roberts Tunnel in honor of the man who played a leading part in bringing about the consummation of the consent decree which finalized Denver's rights to divert water from the Blue River to supply the needs of her rapidly expanding population.

Without detailing the many engineering and geological investigations, reports, and preliminary locations for a tunnel in the area between Dillon and Grant, it can be said that the final location for this monumental undertaking, upon which work is now in progress, is the so-called north dogleg Route. This tunnel will be 23.3 miles in length, have a finished inside diameter of 10 ft, 3 in., and a differential elevation between portals of 178 ft. It will be operated under pressure, and the east portal is designed to serve a 6,000-kw hydroelectric plant to be built later under separate contract. The maximum carrying capacity is 788 fps, or the amount of the 1946 decree for direct flow awarded Denver by court action.

Five individual structures will be required as part of the tunnel facilities: [1] an intake structure; [2] an emergency gate structure situated near the upstream end of the tunnel; [3] an access shaft situated east of the west portal near Montezuma; [4] a surge chamber situated near the eastern end of the tunnel, and [5] an outlet works

at the eastern terminus of the tunnel shown in Fig. 5.

The outstanding feature of these five items is probably the third one—the access shaft. This is a facility required to permit completion of the project within a reasonable period of time. It is planned that this shaft will be situated in the valley of the Snake River, about 8¾ miles from the west portal, with its depth to tunnel grade slightly less than 1,000 ft.

This shaft will be 16 ft in diameter and compartmented to accommodate the facilities used during construction, to remove the material excavated from the tunnel, and to lower concrete and other materials to tunnel level. After completion of the tunnel it is doubtful that this access shaft will ever again need to be utilized.

It is planned, however, to provide a permanent concrete wall around the top of the shaft and a cover consisting of precast concrete slabs. These slabs will be removable with appropriate equipment but heavy enough to be a deterrent to an act of sabotage or unauthorized entry to the tunnel.

It is planned to provide a venturi meter at each end of the tunnel for the measurement of flow through the tunnel.

The time of construction is limited to 2,000 days by the contract, which means that completion should be accomplished in January 1962.

The remaining unit, that of channel improvements downstream from the east portal of the Roberts Tunnel at Grant, has been under study sporadically for the past 2 or 3 years, without completion of definite plans and specifications for the necessary work. As this channel work will not be needed until summer 1962, the delay is understandable.

Acknowledgment

The technical data for this paper have been assembled from the many engineering reports made over the years, particularly that prepared by Alfred J. Ryan, consulting engineer, Denver, who has been employed by the board for all of the design features and some of the supervision on the Fraser River work, and that prepared by Tipton and Kalmbach, Incorporated Consulting Engineers, Denver, also employed on both design and supervision for the Williams Fork and Blue River Projects. Naturally, board files have also been consulted for much of the history related herein.

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Peak Demand Storage

Simon W. Freese

A paper presented on Oct. 16, 1956, at the Southwest Section Meeting, Little Rock, Ark., by Simon W. Freese, Partner, Freese & Nichols, Fort Worth, Tex.

PEAK demand storage, as used in this paper, refers to that storage located on the distribution system and used to help meet peak hourly demands for ordinary domestic and industrial water consumption. This differentiates it from fire flow storage or ground storage used at filter plants or well fields to normalize the daily load.

The purpose of peak demand storage is to provide optimum economy in the cost of distributing water in the required amounts and at the required pressures. Storage at strategic locations provides a two-way feed into the distribution system at times of peak demand and, thus, reduces the required size of distribution mains. Conversely, the addition of storage at the right points increases the capacity of an existing distribution system with deficient system storage. Elevated peak demand storage is an efficient method of maintaining required pressures in the outer sections of a pressure zone and on higher than normal ground within a pressure zone.

Types

There are three general types of peak demand storage commonly utilized on distribution systems: elevated tanks on columns (usually of steel); elevated-ground steel or concrete reservoirs; and ground or underground reservoirs from which water can be relifted into the distribution system during periods of peak demand.

Every city and every pressure plane within a city constitutes a different problem, and each deserves a careful analysis of its peak demand storage requirements. In many instances, however, it is good economy simply to provide sufficient elevated storage to normalize the hourly rates of pumping into the distribution system (during a day of maximum use) in such a way that the main pumping plant may be operated at a uniform rate during the 24 hr of maximum use. Where cheap elevated storage can be provided in the form of concrete reservoirs or steel ground storage tanks on hills of suitable elevation it may prove economical to provide sufficient elevated storage to produce a uniform rate of pumpage over a week of maximum usage.

Curve of Hourly Use

In studying peak demand storage requirements for a day of maximum use, the first requisite is a curve of the estimated hourly use for the year for which the improvement is being planned—perhaps 10, 15, or 20 or more years in the future. The best guide is the actual hourly use experienced on days of maximum use for the city or pressure plane under study. Most cities keep a continuous record of pumpage, but not all keep records of water elevation in the storage tanks riding on the system. If there is existing storage on the system, it is necessary to have records of outflow and

inflow from the storage (as well as the hourly pumpage record) in order to determine the rates of consumption during a day of maximum use. Once this curve is established for the existing population and conditions, it can be modified as an estimate for future population and conditions of use.

In the absence of a satisfactory base record of hourly consumption during a day of maximum use for the particular distribution system under study, a good estimate of hourly use can often be taken from another city or pressure district with population and conditions of use similar to that anticipated for the system under study. In any case, such a "borrowed" hourly use curve provides a good check for the estimated or predicted hourly use curve based on past consumption in the system under study.

Once a curve of hourly use has been adopted, the next step in the study is to derive the ratio of average hourly use to peak demand use. For most southwestern cities and towns, it is believed that this ratio will fall between 60 and 66⅔ per cent. With such ratios, there is no object in supplying more than 33⅓–40 per cent of the peak hourly demand from elevated storage, because they permit pumping at a uniform rate throughout the day of maximum use. The characteristics of most maximum-day hourly-use curves are such that storage on the system of 15–25 per cent of the maximum day's use will normalize the pumping to a uniform rate for the 24 hr.

For cities with surface water supplies, it is necessary to provide this 15–25 per cent of storage as filtered water storage at the filter plant or as elevated storage riding on the distribution system in order to produce a uniform rate of filter plant operation. For cities with well supplies, it is similarly necessary to provide storage at the wells or as elevated storage to normalize the operation of the wells. Many southwestern cities lie in a stream valley or have some other topography suitable for locating elevated storage at elevations where it can be built as ground storage—in concrete reservoirs or steel tanks. In such cases, it is just as economical—sometimes more so—to provide the 15–25 per cent required as elevated storage rather than ground storage at the filter plant or at the well field.

Fort Worth

By way of example, the main pumping plane at Fort Worth (the Holly plane) has suitable locations in plan and elevation for elevated ground storage on three sides. Large concrete reservoirs are located on the north and south sides and an initial 6-mil gal, steel, ground storage tank is planned for the west side of the plane.

The topography of the outer pressure zones at Fort Worth is also propitious for elevated ground storage in the west and south side high service districts. It is planned to install a steel ground storage tank of 7.5-mil gal capacity on a convenient high spot, of the proper elevation, on the far edge of the west side high service district. On the south rim of the south side high service district, a 25-mil gal ground storage reservoir is planned. The latter is designed for possible expansion to 100-mil gal capacity and will be of earth, concrete lined and with a concrete roof, which provides an economical type of construction for ground storage reservoirs of such size. The reservoir is planned not only to help meet peak demands in the south side high service district but it is also planned to act as filtered water storage for a large filter plant on the southeast side

of the city, from which water will be pumped to the elevated filtered water storage and thence to a large part of the city.

As indicated previously, where elevated ground storage is available, everything is to be gained and nothing lost by providing all of the system storage as elevated storage, thereby making it possible to normalize completely the pumping rates. In cities (or in pressure planes within cities) with relatively flat terrain or where sites for elevated ground storage reservoirs are not otherwise available, it is also often economical to provide sufficient elevated tank storage to normalize completely pumping rates during days of maximum use. Only detailed studies of the economics of each city or pressure plane can determine how much elevated storage is justified. Where elevated tanks are required to provide a fire protection reserve or are otherwise justified, it is believed that it will generally be found economical to furnish within 10 per cent of the optimum percentage of peak demand from elevated tanks. By optimum percentage is meant the percentage of the peak demand which will permit pumping at a uniform rate throughout the 24 hr. For example, if 40 per cent of the peak hourly demand taken from elevated tanks with 60 per cent from pumping will iron out completely the pumping rate, then, according to the rule of thumb, it will be found generally economical to provide at least 30 per cent of the peak demand rate from elevated tanks, leaving not more than 70 per cent for the pumps. This 10 per cent leeway makes a substantial difference in the required elevated tank capacity. For example, in one of the larger southwestern cities where the average hourly use equalled 63 per cent of the peak hourly use, the required storage to furnish 37 per cent of the peak hourly demand and to iron out the pumping completely was 21 per cent of the maximum day's use, whereas with 73 per cent of the peak demand from pumps and 27 per cent from elevated tanks, only 12½ per cent of the maximum day's use was required as elevated tank storage to meet the peak hourly demand.

Large Systems

For relatively large distribution systems in one pressure plane, particularly in the case of cities of flat terrain, it is sometimes found economical to meet peak hourly demand by providing system storage in the form of ground storage reservoirs strategically located on the distribution system. Water is bled into the ground storage at night and is then repumped into the distribution system during hours of peak demand. During most of the months of the year, the distribution system is adequate to furnish satisfactory pressures without calling on the storage which is held as an emergency reserve. In such cases, the economic aspect is contained in the question of whether the additional cost of repumping is more or less than the additional fixed charges and maintenance would be on elevated storage compared with ground storage. At anything like equal costs, preference should be given to elevated storage for safety reasons.

Fire Flow

Although the question of how much elevated storage should be provided to meet the required fire flows is a separate study, the peak demand storage and the fire flow storage are closely related, and the results of the two studies must be combined to arrive at the total amount of elevated storage. Table 1 shows the per capita elevated

storage requirements to meet peak demand and fire flow requirements at Fort Worth, Tex., for the estimated 1965 population. For the various Fort Worth water service districts (which are treated as separate units) it was deemed economical to supply 60 per cent of the peak hourly demand plus the fire flow specified by the standard schedule of the National Board of Fire Underwriters from pumpage, and the remaining 40 per cent of peak demand plus fire flow from elevated storage. This table gives some idea of the per capita requirements of elevated storage under the 60 per cent–40 per cent assumption for water districts of various populations in a southwestern city.

TABLE 1

Projected Elevated Storage Requirements for 1965, Fort Worth, Tex.

Water Service District	Estimated 1965 Population	40 Per Cent of 10-hr Fire Flow *mil gal*	Required Per Capita Elevated Storage—*gal*		
			Fire Flow	Peak Demand	Total
West Side	55,700	1.63	29	35	64
North Side	44,200	1.49	34	17	51
South Side	142,200	2.57	18	29	47
East Side	106,000	2.21	21	36	57
Holly Plane	181,300	2.78	15	27	42

Where the Texas Board of Insurance Commissioners' standard of 54.2 gpcd exceeds the combination amount shown by Table 1, the higher figure was used.

The location of system storage to meet peak demand should take into consideration the ultimate development of the pressure plane or district. In general, elevated storage should be located across the pressure plane from the pumping plant; this is almost always required by the topography in the case of elevated ground storage reservoirs. Elevated tanks should be located within the outer edges of the districts opposite the pump stations and, if practicable, on higher ground where the pressure might be weak in the absence of an elevated tank. Almost every city has an elevated tank now obsolete because it was located too near the pump station. As the distribution system or the pressure plane expands, it is necessary to raise the hydraulic grade at the pump station until it lies above nearby elevated storage throughout a day of maximum use.

Having selected the storage capacity in conjunction with a study of the distribution system requirements, a final check must be made of the ability of the mains to fill the storage at night during the period of low use—usually from 10 PM to 7 or 8 AM. The system should also be rechecked to see if the storage can be fed into it during the period of peak demand and whether it can give the desired pressures over the pressure plane.

In this day of increasing loads on existing distribution systems, storage offers many ways of increasing the system peak demand capacity in an economical manner. Each system has its own peculiarities and justifies examination and re-examination from time to time as the load grows.

Effects of Sprinkling Restrictions

Glen D. Heggie

A paper presented on Sep. 12, 1956, at the Michigan Section Meeting, Kalamazoo, Mich., by Glen D. Heggie, Sr. Assoc. Engr., Dept. of Water Supply, Detroit, Mich.

AS a subject for discussion, the effects of sprinkling regulations could be broad enough to include detailed political, economic, technical, and even psychological aspects. It is intended, however, to limit this paper to very general discussion of the experience of Detroit, Mich., with several types of sprinkling regulations. Pumpage records for seasons with sprinkling regulations of different types and for seasons without regulation will be compared and the more obvious effects noted.

If an attempt were made to determine completely the effects on the water supply system of such sprinkling regulations on a year-to-year basis, it would necessitate isolating and considering many factors such as the rapidly increasing use of water for air conditioning, and the type of regulations, if any, imposed on such usage; varying industrial and commercial demands; and increasing domestic water usage, including both a steady increase in population served and a generally noted increase in per capita consumption. Furthermore, weather conditions would certainly be significant in a season-to-season comparison. It has been impossible, however, to evaluate all these factors in the comparisons which follow, and it must be remembered that any conclusions drawn here are general in nature and specific only to the Detroit water supply system. Much study by others has been given to isolating the effects of the sprinkling load from air-conditioning loads, varying industrial and commercial loads and domestic-use loads. Several excellent reports on this phase of the problem are available, such as the papers of Henderson and others (*1*).

Regulations Imposed

The city of Detroit, in 1952, adopted an ordinance to regulate the use of water from the Detroit water distribution system. In its essence, the ordinance placed upon the Board of Water Commissioners the responsibility for prescribing rules and regulations to conserve water supplies whenever the amount of water pumpage reached such a volume that, unless restricted, the public health, safety, and general welfare might be endangered.

Such a situation had arisen on Jun. 16, 1952, when the water levels in the storage reservoirs and suction wells at the Springwells station and the Northeast booster station had dropped so low in the early evening that the Northeast booster stopped its pumps and Springwells station was compelled to curtail its pumpage until the evening peak demand had passed. Although the Water Works Park station had sufficient reserves at the same time, it was unable to give any further assistance to Springwells station or to the area served by the Northeast boos-

ter inasmuch as it was already pumping at maximum capacity. The maximum hour pumpage for the system on this day was at a rate of 1.074 bgd, or 406 gpcd. The 24-hr consumption had pressures far below accepted minimums on that evening, and it was apparent that drastic steps had to be taken immediately to correct the situation. Emergency appeals were broad-

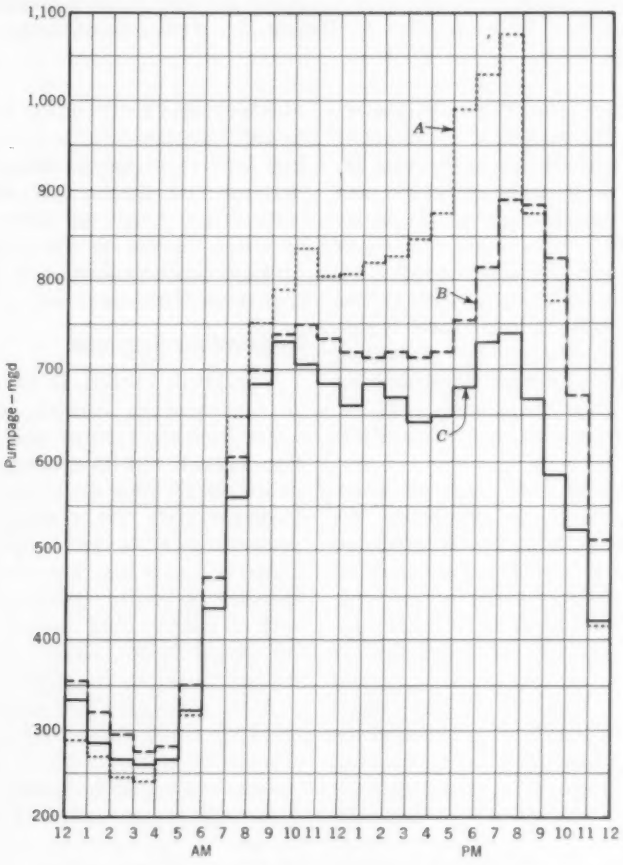

Fig. 1. Effect of 1952 Appeal to Limit Water Usage

Line A *represents 1952 maximum day, unregulated (665 mil gal); Line* B, *maximum day under voluntary restriction (618 mil gal); and Line* C, *the average high day under the 10 AM–9 PM restriction (549 mil gal).*

amounted to 252 gpcd against the annual daily average of 150 gpcd.

Many areas of metropolitan Detroit —principally in the outlying districts— cast and telecast, and late-evening editions of the newspapers carried similar appeals for restriction of all nonessential water usage.

Restrictions

Following the emergency, the Board of Water Commissioners took the following steps to prevent a recurrence:

1. Continued appeals for public cooperation, particularly with reference to nonessential water usage such as sprinkling, car washing, and air conditioning
2. Established reservoir drawdown schedules so that plant operating personnel could insure an adequate reserve in the reservoirs for emergency use
3. Requested the Common Council to adopt an ordinance enabling the board to prescribe rules and regulations to conserve the water supply
4. Accelerated the program for construction of two 10-mil gal reservoirs and booster stations.

Steps 1 and 2 had an immediate and gratifying effect in that, although the daily pumpage remained relatively high subsequent to Jun. 16, the maximum hour rates were substantially lower and the immediate danger appeared to have lessened. It was thought necessary at the time, however, that the voluntary restriction aspect of the problem should be replaced with enforceable rules and regulations. The result was that in July 1952, the third point of the program was fulfilled with the adoption of the requested ordinance and the issuance by the Board of Water Commissioners of a "Text of Rules." These rules prohibited lawn sprinkling between 10 AM and 9 PM, Monday through Friday. Stringent restrictions were also placed on the operation of air-conditioning equipment of the non-water-conserved type. The rules applied in the same manner to suburban communities using Detroit water.

Restrictions were imposed again in the summers of 1953, 1954 and 1955. The 10 AM to 9 PM restriction of 1952 was modified to a 2 PM to 9 PM restriction in 1953, and the "odd-even" system of sprinkling was adopted for 1954 and 1955. (The odd-even system is that under which sprinkling is permitted at odd and even numbered homes on correspondingly numbered days.) The restrictions on air conditioning imposed in 1952 (based on a combination of outside-inside air temperature) were continued without change through 1955. Thus, with the exception of the substantial increase in the air-conditioning load, the effect of the air-conditioning restrictions can be considered as being much the same during the years under consideration.

On the pumpage charts and in the discussion which follows, it will be noted that, except in specific instances, comparisons between consumptions under different types of sprinkling regulations are made on the basis of "average high days" rather than maximum days. An average high day was arrived at simply by taking the hourly average of at least 6 days of high demand. In each instance, an effort was made to select 6 representative days. As an example, in computing the averages, Saturdays and Sundays were excluded, and not more than one Monday was used.

Effects of Restrictions

With the foregoing as background for the imposition of sprinkling regulations, and a brief explanation of the limitations of the methods used in preparing the comparisons, the more obvious effects on the Detroit water system of each type of sprinkling regulation can be considered. The effect of the 1952 appeal for cooperation and the subsequent 10 AM to 9 PM restriction is illustrated in Fig. 1. "Voluntary restriction" refers to the reduction or

elimination of nonessential water usage by the public in response to appeals. That is in contrast with restrictions imposed by law or to the condition of unrestricted or unregulated use. Between the hours of 7 and 8 PM, the maximum day with unrestricted sprinkling gave an hourly rate of 1.074 bgd, whereas with voluntary restriction of maximum hour consumption but only a moderate drop in daily consumption.

Although the 10 AM to 9 PM sprinkling ban of 1952 was successful from the water system standpoint, it was not popular with the consumer. The most common complaint was that the average householder could not get out to sprinkle sufficiently before 10 AM

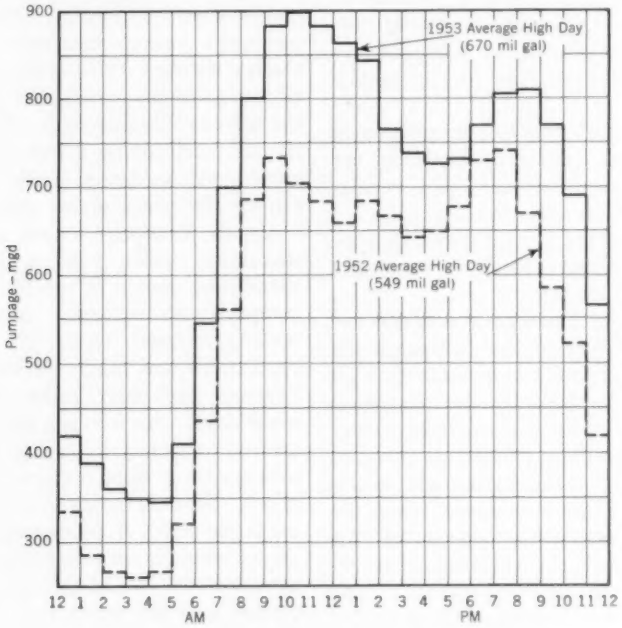

Fig. 2. Comparison of 1953 and 1952 Average High-Day Consumption

The figures for 1953 were recorded under the 2–9 PM ban, for 1952 under the 10 AM–9 PM restriction.

usage the average high day rate dropped to 885 mgd and to a maximum of 740 mgd with the 10 AM to 9 PM restriction in effect. The respective daily consumptions were 665, 618, and 549 mil gal. It can be seen that both the voluntary and the imposed restrictions brought about a significant drop in the

nor long enough after 9 PM to do an effective job. Several aternatives were offered which were intended to overcome or offset some of the objections to the 10 to 9 restriction. After long deliberation it was decided to try the 2 to 9 PM restriction for the summer of 1953.

Figure 2 shows the 1953 average high-day consumption plotted against the 1952 average high day under the 10 AM to 9 PM restriction. In addition to an overall increase in the 1953 consumption for the days compared, there was also a marked increase in the 1953 morning and early afternoon load. The 1953 maximum hour occurred between 10 and 11 AM, indicating that the sprinkling load contributed measurably to the total load until the pronounced 2 PM drop. Comparison of Fig. 2 with 1 shows that the 1953 average high day of 670 mil gal was greater than the 1952 unregulated maximum day in total pumpage, and the 1953 maximum hour was about 170 mgd below the unregulated 1952 maximum hour. In terms of gallons per capita per day, the 1953 average high day represented 247 and the 1952 unregulated day 252 gpcd.

During the summer of 1953, two 10-mil gal underground storage reservoirs plus booster stations were completed and placed in service. This gave the system a total storage capacity of 154 mil gal. There were, however, several days in 1953, with the 2 to 9 PM restriction in effect, when it was impossible to fill these storage facilities completely during the hours of low demand, with the result that the pumpage, to some extent, was then a function of the established reservoir drawdown schedules. This type of pumping resulted at times in low pressures and unsatisfied demands in the outlying districts. When the 2 to 9 PM restriction had been adopted, it was hoped that the average consumer's even sprinkling habits would still prevail and that not too many would avail themselves of the morning and early afternoon sprinkling time. The consumer, however, did not in this case prove to be a creature of habit, with the result that, although public acceptance of the 2 PM ban was somewhat better than that of the 10 AM to 9 PM ban, the 1953 restrictions were quite unsatisfactory from the water system standpoint.

In planning for the 1954 season, working on the assumption that imposed restrictions would be required, it was agreed that a more workable restriction from the system standpoint and one which would meet with a greater degree of public acceptance, would be required. The water system itself (with the addition of the two storage and booster stations in 1953) was now geared to supply water in line with a typical maximum day demand curve as long as the overall demand did not exceed the supply. The odd-even system of sprinkling seemed to be the answer to the problem in that the sprinkling load theoretically would be halved while the demand curve characteristics would remain essentially the same. The odd-even system was therefore adopted for the 1954 season.

On Jul. 27, 1954, the pumpage for the day was 696 mil gal, the maximum for the summer. This had been preceded by several days of pumpage in excess of 600 mil gal and, with the entire system straining to meet the demand, an appeal was made by the mayor for voluntary restriction over and above the odd-even regulation then in effect. The appeal was effective and the hot spell moderated shortly thereafter. The balance of the summer saw some individually high pumpage days, but no further protracted hot spells were experienced. Figure 3 compares the pumpage for the average high day in 1954 with that of 1953. The significant difference between the 1954 average high day and that of 1953

is the leveling effect of the odd-even restriction in 1954. The evening peak hour is in evidence, but certainly not peaked as it would have been without any restriction. The afternoon pumpage in 1954 was quite constant and the evening drop followed more closely the normal pattern associated with unregulated use. Generally, it may be said that the first season with the odd-even regulation was satisfactory in that it accomplished, to a measurable degree, the desired result, and in that the consumers accepted the system surprisingly well.

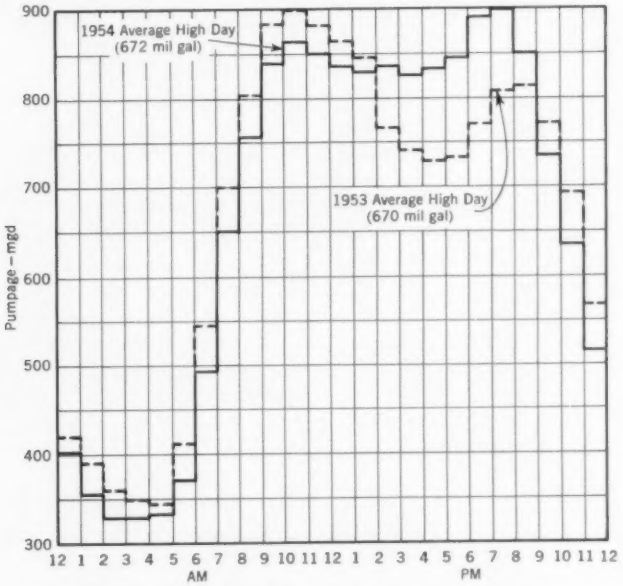

Fig. 3. Comparison of 1954 and 1953 Average High-Day Consumption

The 1954 figures resulted from the odd-even plan, those for 1953 from the 2–9 PM restriction.

even regulation in effect brought about the desired load leveling and, as has been experienced elsewhere, the average daily consumption increased. Although this increase did not appear in the average high-day figures, there was an increase of 5 gpcd for the 1954 season. This increase in consumption, other than that assignable to the general increase in the use of water, probably involves a psychological factor. It is fairly certain that many Detroiters watered their lawns faithfully every other day because it was their day to do so. It is also quite probable that many did so whether or not the grass needed water, so that their turn would not be missed. Basically, the odd-even regulation was satisfactory

The same regulation was imposed again in 1955. Figure 4 shows the comparison of the 1955 maximum day and the average high day compared with the 1952 unregulated maximum

day. The maximum day pumpage in 1955 was 756 mil gal or 267 gpcd. This was the result of a prolonged dry spell together with mid-ninety temperatures for 2 days preceding the maximum day. The maximum hourly rate on the maximum day was 993 mil gal. In comparison with the maximum day and the maximum hour of 1952 with unregulated sprinkling, the maximum day in 1955 showed an increase of 91 mil gal, whereas the maximum hour rate dropped from 1.074 bgd to 993 mgd—a drop of 81 mgd. This reduction in maximum hour rate in the face of a substantial increase in

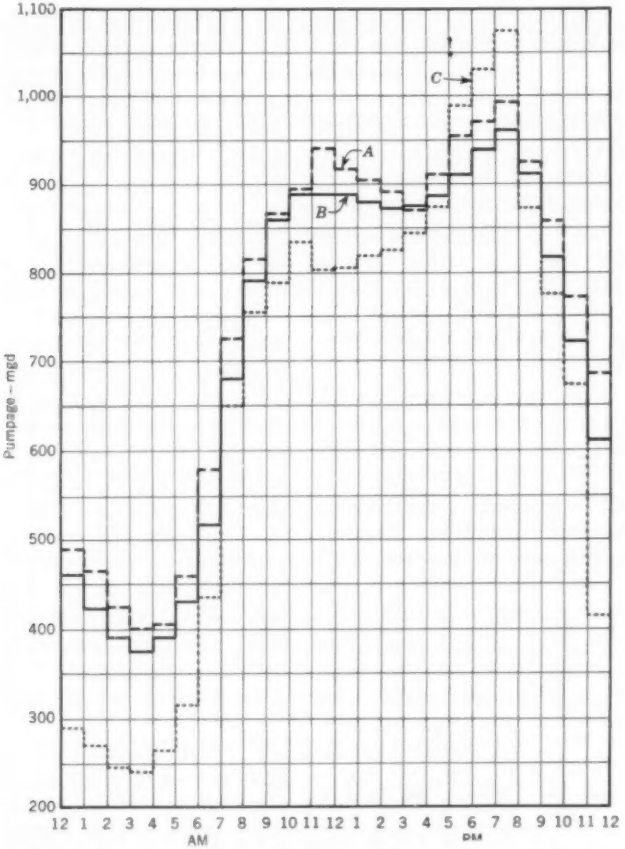

Fig. 4. Comparison of 1955 Maximum and Average High Day With 1952 Maximum Day

Line A *represents 1955 maximum day with odd-even regulation (756 mil gal); Line* B, *1955 average high day under the same limitation (726 mil gal); and Line* C *shows the 1952 maximum day, unregulated (665 mil gal).*

the maximum day pumpage is, perhaps, the most outstanding example of the effectiveness of the odd-even sprinkling regulation.

and then not yet completed, Northeast station in partial operation just 4 days before the maximum day was experienced. On the maximum day, 34 mil

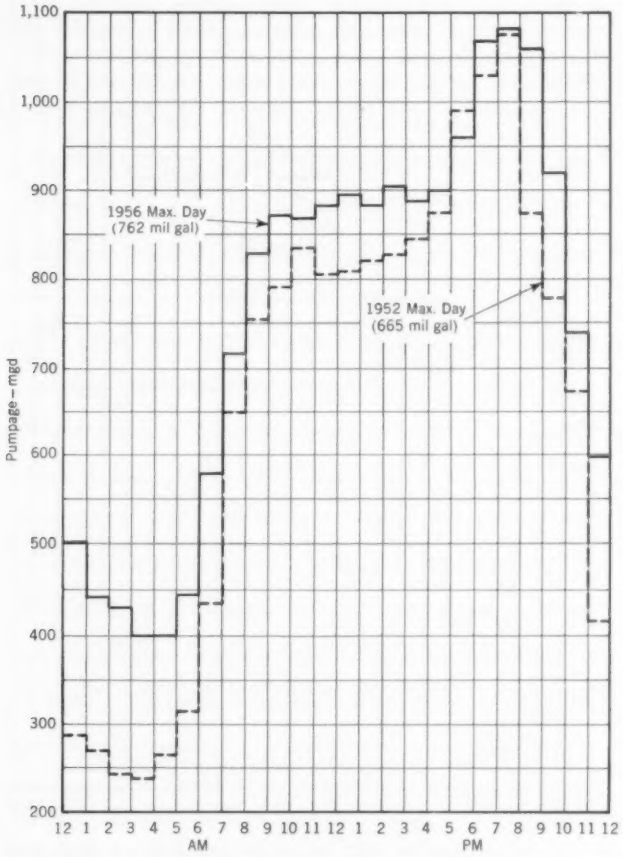

Fig. 5. Comparison of 1956 and 1952 Maximum Days

Both figures are for unregulated periods.

Northeast Station

It might be well to mention that the increased consumption of the 1955 average high day over the 1954 average high day—54 mil gal—was provided for, in part, by placing the new, gal were filtered at the new station and pumped to the mains.

Before the 1956 summer, Northeast station, with the exception of the high-lift plant, was placed in full operation. With the additional capacity of the

new plant available to the system through the 165-mgd pumping capacity of the Northeast booster station, it was decided to enter the summer season of 1956 without imposed regulation, although the enabling ordinance was still in effect so that restrictions could be imposed if the need arose. By means of a concentrated education program, water users were requested to conserve water voluntarily during high-demand hours. It was hoped that with a reasonable degree of cooperation on the part of the consumer it would not be necessary to impose any regulations in 1956. As of this writing, the 1956 season has been relatively cool and wet. The maximum day as of September 1956 (shown in Fig. 5), was in mid June when the daily pumpage reached 762 mil gal or 254 gpcd. This figure of 762 mil gal represents a slightly higher maximum day than the 1955 season, with the per capita consumption 13 gpcd less in 1956. The 1956 maximum hour rate was 1.081 bgd as compared with the 1952 maximum hour rate of 1.074 bgd —a 7 mgd difference—while the 1956 maximum 24-hr consumption increased by almost 100 mgd over the 1952 maximum day.

During the 1956 maximum day, the system pressures were, in general, excellent, whereas there were many areas within the system that were virtually without water during portions of the 1952 maximum day. When it is considered that those areas where the pressures were low in 1952 were, for the most part, the more recently developed areas of Detroit and the suburbs where the lawn-sprinkling load is normally high, and considering further, the fact that the appeals for conservation must have had an effect in reducing the 1952 evening demand, it is estimated that the unregulated 1952 maximum hour might have been an hourly rate of 1.2 bgd or more, had the system been able to furnish water at that rate. This, contrasted with the 1956 maximum hour rate of 1.081 bgd, suggests that voluntary cooperation has been effective.

A note of caution should be injected here, however, concerning the effectiveness of voluntary cooperation in 1956. Consideration of the 1956 pumpage record for the maximum day, and attempts to evaluate the degree of benefit derived from voluntary restrictions, should be based on the fact that Detroit householders had been subjected to 4 years of sprinkling regulations prior to 1956—with the past 2 years the odd-even system. It is suspected by some, and not without foundation, that the odd-even habit was carried over into 1956 and that, had a high demand been experienced later in the summer, a different light might have been shed on the effectiveness of voluntary restrictions. Even so, it is likely that a renewed request for cooperation coupled with adherence to reservoir drawdown schedules would have been sufficient to carry the system through any subsequent high-demand days.

Summary

To summarize, then, the more apparent effects of sprinkling restrictions: Voluntary restriction was effective in 1952 but, because soon thereafter restrictions were imposed by ordinance, it is not known whether or not voluntary restriction would have sufficed for the entire summer. The result of voluntary restriction of usage in 1956 has been encouraging, particularly when the 1956 and 1952 maximum days are compared, but there is no posi-

tive proof that cooperation alone in 1956 would have been sufficient to control the draw on the system had a prolonged hot dry spell been experienced. Of the types of regulated use employed by Detroit to date, the odd-even system has worked well as far as leveling the load on the system is concerned, and the public acceptance of the odd-even system has been good. The 10 AM to 9 PM restriction of 1952 served its purpose from the system standpoint, but was unpopular with the consumer. The 2 to 9 PM restriction employed in 1953 was not nearly as effective as far as benefit to the system was concerned, and, in addition, met with but little better public acceptance than did the previous 10 AM to 9 PM restriction.

It can be said, therefore, that in Detroit, voluntary restriction has proved effective to a measurable degree and the odd-even system provided the least objectionable imposed regulation which accomplished the desired effect on the water system as a whole.

Reference

1. HENDERSON ET AL. The Lawn-sprinkling Load. *Jour. AWWA*, **48**:361 (Apr. 1956).

Correction

The paper "Liquid Alum at Milwaukee" by James E. Kerslake (January 1957 JOURNAL, Vol. 49, pp. 52–54), contained an editorial error. In the last sentence on p. 53, "80–120 ppm" should have read "80–120 lb per million gallons (9.6–14.4 ppm); and "5 ppm" should have read "5 lb per million gallons (0.6 ppm)."

Water Supply From Upland Storage

Leon G. Williams

A paper presented on Sep. 19, 1956, at the Ohio Section Meeting, Toledo, Ohio, by Leon G. Williams, Partner, Jones, Henry & Williams, Toledo, Ohio.

IF the minimum flow of a stream used for water supply is insufficient to meet daily requirements, it is necessary to store water for the dry weather period. Water may be stored in an impounding reservoir (created by constructing a dam across the valley of a stream) or in upland storage, where water is pumped from the stream into the reservoir.

An upland reservoir may be formed either by constructing a dam across the mouth of a ravine or by surrounding an area with a levee. In either method, water is pumped from the main stream into the storage space thus formed. This paper deals primarily with upland storage of the latter type.

Advantages in Upland Storage

Favorable characteristics of upland storage compared with impounding reservoirs include the following:

1. It is possible to select the water to be saved and pump to storage only water of relatively good quality. Flood flows that are heavily loaded with sediment may be bypassed, thereby avoiding the deposit of solids in the reservoir.

2. The maintenance of reasonably uniform, good quality water in the reservoir facilitates treatment and reduces the amount of labor and chemicals required.

3. No spillway is required for flood flow in the main stream because the channel is left unobstructed. Thus, the cost of the spillway is avoided, as well as the hazard of washing out an impounding dam if the flood exceeds the spillway capacity.

4. The area flooded is controlled by the enclosing levee and a steep shore line along the levee is provided for the entire periphery. Extensive shallow water areas which may contribute to growth of vegetation and accompanying objectionable tastes and odors are thus avoided. Further, the area flooded may be kept to a minimum in relation to storage volume, thus reducing evaporation losses. With a steep shore line that is short and regular, a mosquito problem is not likely to occur and the reservoir can be controlled with minimum effort.

Disadvantages

Disadvantages of upland storage compared with impounding reservoirs include the following:

1. It is impracticable to catch all of the water during flood flow because the quantity recovered depends on capacity of the raw water pumping station.

2. Upland storage does not lend itself to multi-purpose development—such joint uses, for example, as flood control, wild life conservation, or de-

velopment of recreational areas are not consonant with this type of storage. Except possibly for fishing, upland storage is essentially for water supply only.

The water supply is obtained from wells at a limestone ridge about 11 miles southeast of the city, augmented by surface water from the Blanchard River. The well field has a limited capacity of about 1 mgd, and during the summer months the discharge of the Blanchard River has dropped to practically zero for weeks in succession.

In 1947, an investigation of means of improving the water supply led to adoption of upland storage using water pumped from the Blanchard River

TABLE 1

Summary of Estimated Costs at the Various Reservoir Sites, Findlay, Ohio

Reservoir Capacity—*mil gal*	Site 1	2	3	4*	5*	6
			Total Project Cost—*dollars*			
500	839,000	668,000	1,077,000	890,000	1,201,000	1,126,000
1,000	1,018,000	895,000	1,289,000	1,204,000	1,448,000	1,398,000
1,500	1,232,000	1,108,000	1,620,000	1,597,000	1,750,000	1,698,000
2,000	1,498,000	1,303,000	1,831,000	——	2,041,000	1,983,000
2,500	1,650,000	1,506,000	2,018,000	——	——	——
3,000	1,822,000	1,735,000	2,396,000	——	——	——
			Land, Levee & Riprap Costs Only—*dollars*			
500	510,000	374,900	380,400	486,000	765,000	386,000
1,000	688,000	560,000	555,000	745,000	969,000	619,800
1,500	839,800	710,000	725,000	1,015,000	1,184,180	761,000
2,000	1,030,000	835,000	875,000	——	1,394,180	891,000
2,500	1,130,000	970,000	1,005,000	——	——	——
3,000	1,240,000	1,120,000	1,105,000	——	——	——
			Land, Levee & Riprap Costs per Million Gallons of Reservoir Capacity—*dollars*			
500	1,020	750	760	972	1,530	772
1,000	688	560	555	745	969	620
1,500	560	472	483	677	790	507
2,000	515	418	438	——	697	446
2,500	452	388	403	——	——	——
3,000	414	372	368	——	——	——

* Sloping site.

Conditions at Findlay, Ohio

Findlay, the county seat of Hancock County, Ohio, is a community that recently adopted upland storage. Its 1940 population of 20,228 grew to an estimated 26,200 in 1955, and water treated in this period increased from 1.81 mgd in 1940 to 3.25 mgd in 1955.

which, at Findlay, has a drainage area of about 240 square miles at a point of diversion for water storage. The average discharge is about 208 cfs. Prolonged periods of low discharge are of particular concern for determining the necessary storage capacity. Predictions based on the character of the drainage area and the available record of rainfall and discharge indicated that stored water sufficient for 7 months use would be required on a frequency of once in 50 years and for a 10-month period, once in 100 years.

The capacity required for the raw water pumping station was determined from a study of mass diagrams of river discharge following drought periods, and were found to range from 20 mgd for a reservoir of 500 mil gal to 60 mgd for a reservoir of 3 bil gal capacity.

Surveys were made of six reservoir sites located east or south of the city. Sites 1 and 2 were on reasonably flat flood plane of the Blanchard River and adjacent to the existing 24-in. pipeline from the ridge well field to the city. Site 3 is about 2 miles north of the river on a reasonably level hilltop, approximately 50 ft above the Blanchard River flood plane. Sites 4 and 5 are on sloping terrain between the river and Site 3. Site 6 lies 2.5 miles south of Findlay water works on a flat area which includes abandoned clay pits. At all of the locations, suitable material for construction of the levee was available on the site or within reasonable haul.

Cost Estimates

Study layouts covering a range of reservoir capacities from 500 mil gal to 3 bil gal were made for the various sites. Estimated costs are summarized in Table 1. Site 1 was high in land cost and construction cost because of the necessity of removing deep top soil. Site 2 proved to be the most economical and was the preferred site. Sites 3 and 6 were economical for reservoir construction but high in pipeline and pumping cost. Levee costs on Sites 4 and 5 were 30–50 per cent more than those at the other sites, and reflect the high cost of constructing a reservoir on sloping ground.

At Site 2, the estimated project cost varied from $668,000 for a 500 mil gal reservoir to $1,735,000 for a reservoir of 3 bil gal capacity. These figures include the cost of the land, the diversion dam and intake, the raw water pumping station, the reservoir, and the outlet chamber. The estimated cost of the reservoir only, per million gallons capacity, varied from $750 for a reservoir of 500 mil gal capacity to $372 for a reservoir with 3 bil gal capacity.

Design and Construction

Plans were prepared for a reservoir at Site 2 with a storage capacity of 1.3 bil gal and a raw water pumping station with a capacity of 30 mgd.

The levee was designed with height of 25 ft above the normal ground surface, with the top width 12 ft, outside slope 3:1, inside slope 2.5:1, and with a berm 16 ft wide and 20 ft below the top. The inside slope above the berm was protected with crushed stone riprap. The outside slope was covered with 8 in. of seeded top soil.

Work was started in April 1949 and completed in October 1949. The reservoir site had been thoroughly tiled as farm land. After stripping the top soil, one of the first operations was to excavate a trench 12 ft in width on the line of the proposed levee to sufficient depth to cut all tile lines passing under

the levee. The trench was backfilled with compacted clay, forming an impervious core completely around the reservoir.

All fill material for the levee was excavated from inside the reservoir, using pans for short-haul material excavated near the levee and an elevating grader with Euclid Wagons for the longer-haul material taken from the central area of the reservoir. From 12,000 to 14,000 cu yd of fill was placed in a normal day. Compaction was accomplished with tamper type sheepfoot rollers loaded to not less than 1,100 lb per linear foot of tread. Moisture was carefully controlled to optimum for compaction by sprinkling if too dry or disking to increase evaporation if too moist.

A portable soil testing laboratory was maintained throughout the work for continuous checking of the character and moisture content of the fill material and of compaction in the levee. The tests were recorded systematically on printed forms and made a part of the daily construction reports.

The work was contracted in two parts: Contract 1, or the reservoir contract, included the outlet structure, control chamber, and connection to the existing 24-in. vitrified clay pipeline which passed the reservoir enroute from the well field to the city. The outlet structure had ports with sluice gates at three elevations to permit water to be drawn off from any desired level. A bar screen is provided to prevent large solids from entering the outlet conduit. The control chamber was located outside the levee and contained a regulator which automatically adjusts the discharge from the reservoir to whatever deficiency there may be in the flow from the well field. Reservoir water mixes with the well water and flows through the 24-in. pipeline to the city.

Contract 2 included a low diversion dam in the river, a 48-in. diameter intake conduit, a pumping station, and an inlet conduit to the reservoir. The diversion dam is a simple concrete structure about 3 ft high and founded on rock of which the river bed is com-

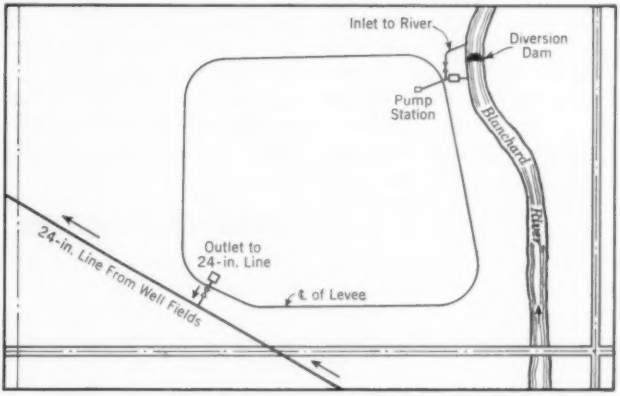

Fig. 1. Layout of Upland Storage Installation at Findlay, Ohio

posed. The inlet conduit was constructed of reinforced concrete pipe laid in rock trench. A mechanically cleaned bar screen was installed at the entrance to the pumping station.

Space is provided in the pumping station for three motor-driven vertical centrifugal pumps with a capacity of 10 mgd each. Two units were included in the initial installation, with space for the third unit when required. A 36-in. venturi meter was provided to measure all water pumped to the reservoir. Construction of the pumping station was started in June 1949 and completed in May 1950.

A layout of the installation is shown in Fig. 1 and construction costs for the entire project are summarized in Table 2.

TABLE 2

*Costs for the Upland Storage Installation at Findlay**

Contract 1—Reservoir		
Clearing of site and removal of top soil	$ 87,124.73	
Reservoir excavation and embankment 1,010,458 cu yd at 29.6 cents per cubic yard	299,095.57	
Concrete work and reinforcing steel	38,478.07	
Riprap on levee	111,332.36	
Roads	19,324.48	
Outlet structure, regulating chamber and miscellaneous	59,534.60	
Total		$614,889.81
Contract 2—Pumping Station		
Diversion dam and intake flume	$ 25,419.75	
Pumping station: Structure	59,254.11	
Equipment	109,596.62	
Total		$194,270.48

* Total cost of project: $809,160.29.

Operating Experience

Fortunately, the pumping station was completed in time to take advantage of a short period of runoff in the river which occurred in May and early June. In June the reservoir was filled, and this proved to be the last period of substantial runoff for the entire season; 2 months later the river was dry. The stored water carried the city comfortably through the drought period.

In an ordinary year, water in the reservoir is drawn down 8–10 ft during the summer and fall. The greatest drawdown to date is 19 ft—which corresponds to a volume of water without drawn from storage equivalent to about 8 months use. According to preliminary estimates this should occur on an average of once in about 60 years. In this case it occurred near the beginning of the period.

The reservoir is filled mainly during the spring months of flash runoff when hardness of the river water is low. Based on average figures taken from the daily reports for the 4-year period prior to construction of the reservoir (1946–1949) and on figures for the 4-year period with the reservoir

in use (1951–1954), the total hardness of the reservoir water averaged 100 ppm less than the average of the river water previously used. The experience at Findlay is another example of good quality water secured on a sound and economical basis through the use of upland storage.

Acknowledgment

K. B. Woods and E. J. Yoder of Purdue University were consultants on earth-work and embankment control. Otto C. Gohlke, City Engineer and Superintendent of Findlay Water Works was in general charge of the project. A. V. Foltz, Assistant Superintendent, had immediate charge of construction and field inspection. The author wishes to express his appreciation of their assistance on the work and in supplying information and operating records used in the preparation of this article.

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Ground Water in the South Carolina Coastal Plain

George E. Siple

A paper presented on Mar. 23, 1955, at the Southeastern Section Meeting, Savannah, Ga., by George E. Siple, Dist. Geologist, USGS, Columbia, S.C. Publication is authorized by the Director, USGS, Washington, D.C.

THE ground water resources of the coastal plain of South Carolina compare favorably in both quantity and quality with those of most other areas of the United States.

Presented here are some of the salient features of the occurrence of ground water in this part of South Carolina, with particular emphasis on its broad relationships of geology, hydrology, and geochemistry. The US Geological Survey, in cooperation with the State Development Board, is currently engaged in ground water investigations in South Carolina, and most of the data presented herein were obtained during the course of these investigations.

The areal geology is considered first because it represents the primary factor controlling the occurrence and movement of ground water. Next, some hydrologic concepts are discussed, particularly as they relate to aquifers in the coastal plain. Finally, the geochemical aspects of waters obtained from the aquifers are considered.

Stratigraphy

The South Carolina Coastal Plain is composed of a series of unconsolidated to semiconsolidated sedimentary formations, deposited with a simple homoclinal structure on an ancient peneplain underlain by crystalline rocks. The basement rocks consist of granite, gneiss, slate, chlorite, hornblende schist, sericite schist, and pyroclastic rocks. In some places these rocks are injected by diabase dikes of Triassic age. Downfaulted valleys in the crystalline rocks were filled with sediments during Triassic time, and these sediments, now consolidated, crop out at the present land surface in the Piedmont area and come to the surface of the basement rocks underneath the coastal plain.

The basal peneplain of crystalline rocks has a northeast-southwest strike and dips to the southeast at 10–35 ft per mile. The most significant structural deformation of these older rocks is an anticlinal uplift in the northeastern part of the coastal plain, commonly referred to as the "Great Carolina Ridge." The effect of this structure upon that of the formations of the coastal plain is observed in the southern, and, possibly, even southwestern component of dip that these units have in the Peedee River area. Thus, formational tops in Horry County are found at higher altitudes than those observed in the Santee River area, along the strike, and to the south and southwest.

The presence of sandstones and diabase of Triassic age in the subsurface at altitudes near that of the crystalline

basement may be responsible for the absence of the older Late Cretaceous strata (the Tuscaloosa formation) in the area between Georgetown, S.C., and Wilmington, N.C. However, although the absence of these beds is rather definite in the Wilmington area, there is considerable doubt as to whether they are absent in the South Carolina area.

Of further significance is the evidence of a basinal structure under the area of the present Savannah River Valley. In this region occurs the thickest section of sedimentary beds in the state.

Overlying the basement rocks is a series of unconsolidated to semiconsolidated sediments consisting of gravel, sand, clay, limestone, marl, and shale. In ascending order they represent deposits of Late Cretaceous, Tertiary, and Quaternary (Pleistocene) age. Their strike is northeast-southwest and they dip to the southeast at 8–30 ft per mile, the greater dips being in the deeper-lying strata.

The principal aquifers, as far as potential yield and utilization are concerned, are the Tuscaloosa formation, the Peedee and Black Creek formations, the Santee limestone, and the Cooper marl.

Tuscaloosa Formation

The Tuscaloosa formation is the basal unit of the formation in the coastal plain and is of Late Cretaceous age. It crops out in a belt 10 to 40 miles wide, extending in a northeast-southwest direction along the inner margin of the coastal plain. The formation has a smaller dip (15–20 ft per mile) near the landward margins than it has across the coastal plain as a whole (30 ft per mile). The unit consists of tan, buff, red, and white crossbedded, micaceous, feldspathic, quartz sand and gravel interbedded with red, brown, gray, and purple impure clay and white kaolin. Its thickness ranges from a featheredge in the vicinity of the fall line to approximately 800 ft in wells near the coast. In general, the unit represents a continental phase of deposition in the outcrop area, although some features of marine or lagoonal deposition also have been observed. Within and along the southeastern margin of the outcrop area are minable deposits of kaolin. The kaolin occurs in lenticular bodies which extend laterally for several square miles and have a maximum thickness of 30–45 ft. They are responsible for the existence of perched ground water in sands overlying the kaolin, and the availability of this water in sufficient quantities for domestic uses has retarded the development of the deeper ground water.

Black Creek and Peedee

Unconformably overlying the Tuscaloosa formation are the Black Creek and Peedee formations, which are younger deposits of Late Cretaceous age and equivalent to the Navarro and Taylor groups of the Gulf series. The two formations in South Carolina are similar to each other in lithologic composition, aquifer characteristics, and quality of included ground water. In many places, particularly in the subsurface, the two formations cannot be distinguished solely on the basis of their lithology. In general, however, the Peedee is more calcareous and fossiliferous, whereas the Black Creek formation consists mostly of fine to medium phosphatic and glauconitic sands interbedded with gray and black clay. The upper part of the Black Creek formation, the Snow Hill marl

member, is profusely fossiliferous; the lower part contains fewer fossils. Stephenson (*1*) identified only three molluscan species from the basal beds of the Black Creek, whereas the Snow Hill marl member yielded 140 species.

Both the Black Creek formation and the Peedee formation crop out in the northeastern third of the coastal plain and underlie younger sediments in the remainder. They dip south-southeast at a rate that averages approximately 23 ft per mile in the area as a whole. Possibly, the average rate does not apply in the northeastern area where the dips are erratic because of such structural features as the Great Carolina Ridge and the presence of buried Triassic rocks.

The combined thickness of the Black Creek and Peedee formations approximates 1,400 ft in wells in coastal areas.

Although some parts of the Black Creek formation appear to represent continental facies, the greater part of this formation and all the Peedee formation are of marine origin. The dark-gray to black clay beds of the Black Creek are organic and pyritic and were deposited in quiet, and, presumably, rather deep waters.

Santee Limestone Formation

Another principal aquifer is composed of the Santee limestone and Cooper marl of Eocene age. This aquifer probably includes some limestone of Oligocene age. In Georgia and Florida the aquifer is referred to as the Ocala formation. In South Carolina, the formation crops out in an arcuate belt approximately 25 miles wide, extending from Allendale County on the Savannah River, eastward to the Santee River and the northern part of Charleston County. The Santee limestone is soft in most places, but in weathered exposures it contains ledges of recalcified and indurated rock. Some sampled intervals of the formation, obtained from test wells in the southern part of Beaufort County, also were indurated. The color ranges from a pure white to a coffee brown. In many places the rock is profusely glauconitic and has a greenish tinge. In the northern part of the outcrop area, the formation contains caverns or caves, through which considerable quantities of ground water discharge into surface streams or lakes. The cavernous structure has an important bearing on the hydrologic characteristics of the unit.

McBean Formation

The McBean formation, of middle Eocene age, is an important aquifer in the area southwest of the Congaree River. It consists of yellow, tan, and greenish-brown glauconitic, quartz sand intercalated with red, yellow, tan, and green clay, sandy marl, and lenses of siliceous limestone. The strike of the formation is approximately N. 60° E. and the dip 8–9 ft per mile to the southeast. Its maximum thickness is about 250 ft, and, from the data available, this thickness does not appear to change appreciably between Barnwell County and Beaufort County. The formation is almost entirely marine in origin. Figure 1, a geologic section of the western part of the coastal plain, shows the structure and thickness of the McBean, and Fig. 2 shows a generalized profile section of Aiken to Beaufort counties. This area was selected to illustrate features of the stratigraphy and hydrology found in most of the coastal plain, because, in this area, more closely spaced, deep wells have been drilled than in any other, and more detailed geologic and

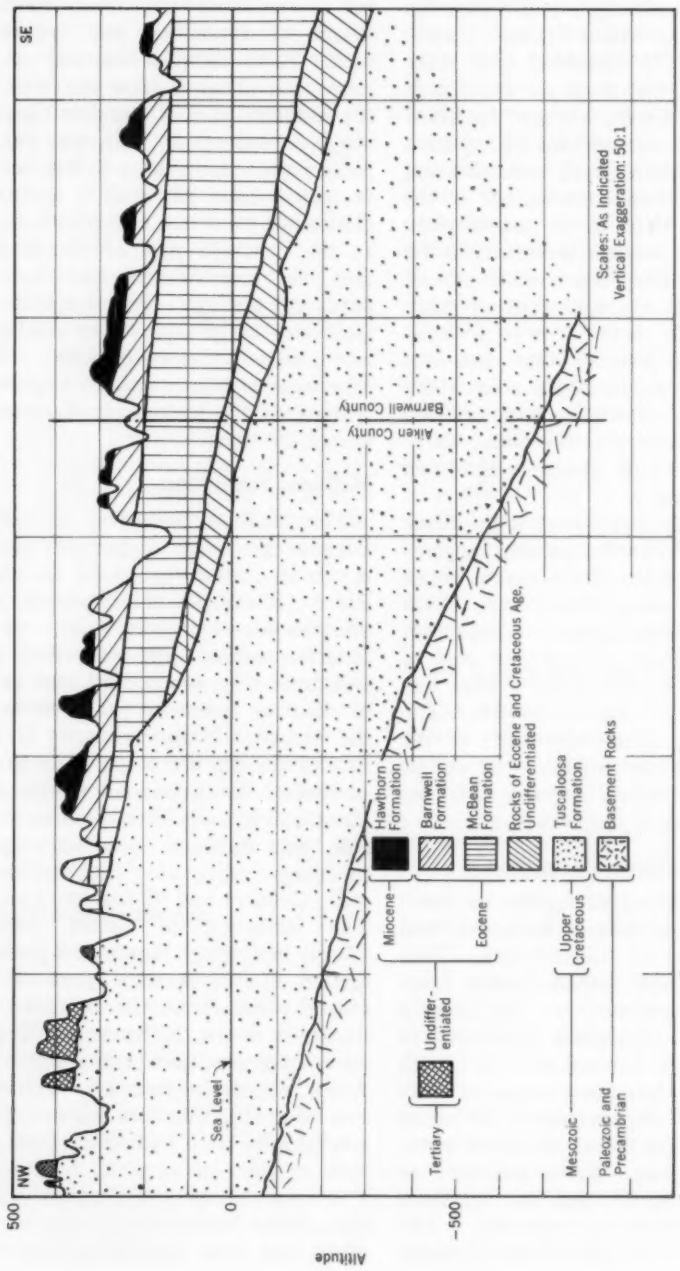

Fig. 1. Geologic Section of Western Part of Coastal Plain

hydrologic data have been obtained here than in other parts of the coastal plain.

Of secondary importance, as aquifers, are the remaining deposits of Tertiary to Pleistocene age. These include the Black Mingo formation, Barnwell formation, Cooper marl, Hawthorn formation, Duplin marl, and Waccamaw formation, all of Tertiary age, and the formations named from the separate Pleistocene terraces. With the exception of the Barnwell formation, these units occur as thin, nearly horizontal deposits which have been eroded from many parts of the coastal plain. In fact, the hydrologic importance of such units as the Waccamaw formation, the Barnwell formation, and, perhaps, parts of the Cooper marl, lies in their ability to serve as aquicludes (confining beds) rather than as aquifers. Considering the entire group, the utility as aquifers has been confined principally to domestic or limited industrial needs. However, it is true also that, in some places, an adequate supply of water in these shallow aquifers is being overlooked because of the presence of the better known, deeper supplies. In much the same manner, the development and use of shallow flood plain aquifers, which are recharged by infiltration from surface streams, has lagged, but these aquifers probably will be used more extensively as drilling techniques improve and additional knowledge of their location and extent is obtained.

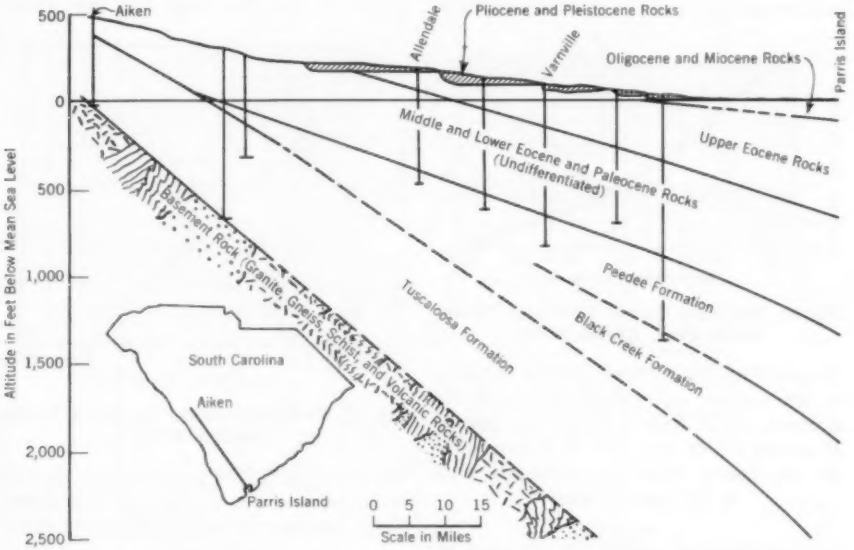

Fig. 2. Generalized Profile and Structure Section Aiken to Beaufort Counties, S.C.

Ground Water Hydrology

Approximately 45–50 in. of rainfall is reported by the US Weather Bureau as representative of the range of average precipitation in the eastern or coastal plain section of South Carolina. From streamflow data obtained

by the USGS, the author calculated the average runoff in those streams originating in the coastal plain as approximately 14 in. annually. Figures 3 and 4 represent duration curves prepared by the USGS for the 20-yr records obtained at gaging stations identified as the South Fork of the Edisto River near Montmorenci, S.C., and Lynches River at Effingham, S.C. These curves can be used to obtain an estimate of the amount of ground water discharge. It can be assumed conservatively that the discharge which

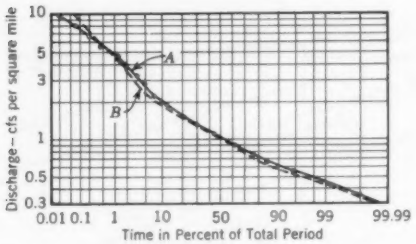

Fig. 3. Duration Curves for Daily Flows, South Fork, Edisto River

Prepared by USGS from 20-year records of streamflow data gathered at Montmorenci, S.C. Line A is for the period of record (1941–51), line B is computed for the period 1932–51. Drainage area is 198 square miles.

is equaled or exceeded 99 per cent of the time represents a minimum figure for ground water discharge into the streams. Converted into inches, the discharge of the Lynches River at Effingham equaled or exceeded, 99 per cent of the time, amounts to an average of more than 2 in. of depth over the whole drainage basin. The same figure for the South Fork of the Edisto River is more than 5 in. A more generous estimate for ground water discharge would be that flow which is equaled or exceeded 70 per cent of the time. This figure is arbitrary but does not appear unreasonable. Calculated in this manner, the annual ground water discharge to the Lynches River and the South Fork of the Edisto River might average as much as 6 and 11 in., respectively. The Lynches River basin extends into the Piedmont province, where higher rates of surface runoff prevail. It is, thus, likely that the runoff from the coastal plain part of its basin includes a higher proportion of ground water discharge than is shown by the data for the whole

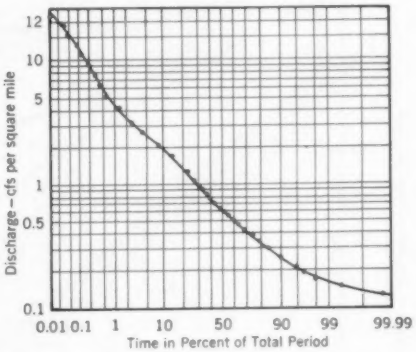

Fig. 4. Duration Curves for Daily Flows, Lynches River

Prepared by USGS from 20-year records of streamflow data gathered at Effingham, S.C. Drainage area is 1,030 square miles.

basin, so that the indicated range of 2–6 inches is too low, and the figures for the Lynches should be almost the same as those for the South Fork of the Edisto. The duration curves for the two streams represent conditions as they occur in widely separated parts of the coastal plain; doubtless, they are reasonably representative of the coastal plain as a whole.

The median of the values computed above approximates 6 in. of ground water increment per year. Because of

the conservativeness of the method of estimation, the increment probably exceeds this amount.

Ground water in the coastal plain occurs under both water table and artesian conditions. In the former, the water surface is unconfined (under atmospheric pressure) and is free to move in a vertical direction. Under artesian conditions, the water in the aquifer is confined under a relatively impermeable bed, and hydrostatic pressure on the water causes it to rise above the bottom of the confining bed when the aquifer is penetrated by a well. Water in the shallow aquifers almost always occur under water-table conditions, whereas water in the deeper aquifers is usually artesian.

The piezometric surface of water in an artesian aquifer is an imaginary surface which represents the height to which water will rise in tightly cased wells that tap the aquifer. Piezometric maps (contour maps on the piezometric surface) are useful in determining areas of recharge and discharge for any aquifer, and the direction of movement of the water. Areas of highest altitude on the piezometric surface are areas of recharge to the aquifer; those of lowest altitude are

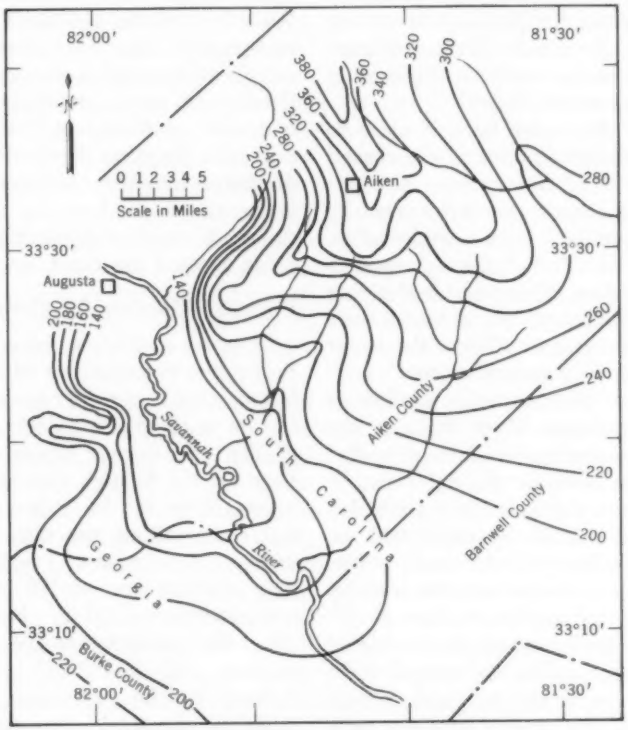

Fig. 5. Piezometric Map of Artesian Water in the Tuscaloosa Formation

areas of discharge. The direction of ground water movement is normal to the piezometric contour, and is from a point of higher potential to one of lower potential. Figure 5 represents the piezometric surface of artesian water in the Tuscaloosa formation in Barnwell and Aiken Counties, S.C., and Burke County, Ga. The relatively low position of the piezometric surface along the Savannah River indicates that the artesian water is discharging into the Savannah Valley.

Because the water table is close to the land surface in most of the coastal plain, the shallow aquifers are recharged in almost the entire area by direct accretion from precipitation. Discharge is effected through loss to springs, lakes, streams, underlying artesian aquifers (in places where their piezometric surface is below the water table), and evapotranspiration.

Recharge to an artesian aquifer is more complicated than that to the water table aquifers, and is controlled in large measure by the difference in head between the water in the artesian aquifer and that in the water table or artesian aquifers above and below. Recharge can take place in the outcrop areas, although studies to date on recharge of the Tuscaloosa formation in the western part of the coastal plain show that, contrary to some widely held beliefs, the aquifer receives most of its recharge by leakage from overlying aquifers and actually discharges in the outcrop areas. All artesian aquifers must be considered "leaky" to a greater or lesser extent, depending upon the nature and thickness of the confining beds. Jacob (*2*) has described these conditions and published equations for computing drawdown in a leaky aquifer.

With reference to the Atlantic Coastal Plain, such "leaky" recharge from above takes place along or contiguous to the outcrop area and down the dip to the extent that the head in the artesian aquifer is higher than that in the overlying aquifer (whether artesian or water table). The aquifer discharges the water into units having lower hydrostatic heads. Thus, water recharged to an aquifer along the inner margin of the coastal plain moves down the dip (or, more accurately, down the hydraulic gradient which may be in a different direction from the dip) to discharge into the overlying strata in areas where its head is lower than theirs, between the outcrop and the coast, beyond the coast, or both.

Factors Affecting Aquifers

In order to evaluate or compare the hydrologic potentialities of aquifers, it is necessary to consider such additional factors as their permeability, transmissibility, and storage capacity. As defined by the USGS, the coefficient of permeability is the rate of flow of water, in gallons per day, through a cross-sectional area of 1 sq ft, under a hydraulic gradient of 100 per cent, at a temperature of 60°F. For ordinary use, the temperature correction is omitted, and the "field" coefficient is defined for the prevailing conditions, including the local water temperature. The coefficient of transmissibility is the product of the field coefficient of permeability and the saturated thickness of the aquifer.

The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

Another factor in common use, especially among drillers and others engaged in the design of water supply systems, is the specific capacity, which is used in reference to a particular well. This is defined as the rate of yield per unit of drawdown (generally, gallons per minute per foot) and it can be determined from either a flowing or a pumped well. The measured drawdown may vary considerably among several wells because of "entrance losses"—losses in head as the water enters the well and flows up the casing. They are determined more by the construction of the well than by the characteristics of the aquifer.

Table 1 lists the coefficients of transmissibility and storage of the most important aquifers in the coastal plain of South Carolina as calculated from pumping tests made in various parts of the area.

The permeability of the Tuscaloosa formation is relatively high, and in several areas yields up to 2,000 gpm can be obtained from individual wells. The transmissibility of the Tuscaloosa is apparently greatest in areas 20–40 miles downdip from the outcrop, decreasing from there in both the updip and downdip directions. The increase in the transmissibility of the aquifer downdip from the outcrop may be due to the increase in aquifer thickness in that direction, rather than to an increase in permeability.

The data on the Black Creek and Peedee formations are based on only a few pumping tests. Other factors, however, indicate that their permeability is considerably less than the maximum values obtained for the Tuscaloosa formation, although the permeability of the Black Creek formation possibly equals that of the Tuscaloosa in downdip or coastal areas. Yields as high as 1,200 gpm have been reported from wells in the Black Creek formation, but usually such quantities are obtained downdip from the outcrop area, where a thicker section of the unit is found. Yields of this magnitude are reported from wells having a minimum diameter of 8–10 inches, a depth of 600–900 ft, and, usually, a gravel-packed finish.

One of the principal difficulties encountered in obtaining reliable data concerning the piezometric surface or permeability of coastal plain aquifers derives from the fact that many wells have screens set opposite several aquifers, and the data obtained from measurements at the well head represent some average of the values pertinent to the individual aquifers.

According to the available information, the transmissibility of the Ocala limestone is comparable in some areas to that of the Tuscaloosa formation. Data from pumping tests made in both South Carolina and Georgia indicate that the transmissibility of this aquifer is considerably higher in Georgia. This may be accounted for, in part, by the increased thickness of the aquifer in Georgia, but it has been determined also that the deeper parts of the aquifer in South Carolina are much less permeable than the upper few tens of feet. Yields of wells in this formation have been reported to be as high as 2,000 gpm, and some drillers have indicated that even higher yields were possible. These yields are usually obtained from wells 8–10 in. in diameter which have been cased to the top of the limestone, and are open for at least several feet in the aquifer. It seems probable that, if pumping tests were made on wells in those areas

TABLE 1

*Aquifer Characteristics in the South Carolina Coastal Plain**

Location	Depth *ft*	Diameter *in.*	Aquifer	Yield *gpm*	Drawdown *ft*	Specific Capacity *gpm per ft*	Coefficients		Alignment of Data
							Transmissibility†	Storage‡	
Aiken County	665	8	Sands of Late Cretaceous age	370	16	23.1	46,000	0.0004	Good
Aiken County	860	8	Sands of Late Cretaceous age	1,530	42	37	400,000	0.0002	Fair
Aiken County	825	8	Sands of Late Cretaceous age	1,870	47	39.8	250,000	0.0007	Good
Aiken County	830	8	Sands of Late Cretaceous age	605	16.4	36.9	250,000		Fair
Aiken County	165	8	Sands in McBean formation	175	11.6	15.1	7,200		Fair
Barnwell County	680	8	Sands in Tuscaloosa formation	1,500	45	33.3	90,000	0.0003	Fair
Williston	700	8	Sands in Late Certaceous age	530	16.4	32.3	120,000		Fair
Bethune	194	18	Sands in Tuscaloosa formation	300	118	2.5	3,500	0.00023 to 0.0004	Fair
Dillon	593	8	Sands in Tuscaloosa formation	400	27	14.8	55,000	0.003	Poor
Sumter	714	10	Black Creek and Tuscaloosa§	1,100	27	53.1	84,000		Fair
Sumter	607	8	Black Creek and Tuscaloosa§	900	33	27.3			
Georgetown	912	8	Sands in Peedee and Black Creek formations	150	42	3.6	1,700		Good
Leesville	93	10	Sands of Eocene age	110	64	1.7	6,300		Poor
Leesville	88	10	Sands of Eocene age	150	28	5.4	14,000		Fair
Burton	100	10	Limestone of Tertiary age	225	14	16.1	26,000	0.00004	Fair

* Data determined by pumping tests.
† The product of the field coefficient of permeability and the saturated thickness of the aquifer.
‡ Volume of water released from or taken into storage per unit surface area.
§ Stratigraphy uncertain.

underlain by the cavernous limestone, both yields and calculated transmissibilities would be much higher. At St. Marys, Ga., wells drilled into this aquifer have flowed at rates as high as 4,000 gpm.

The McBean formation is relatively permeable in the area between the Savannah and Edisto rivers. In this area, the coefficients of transmissibility obtained from several pumping tests ranged from 8,000–100,000 gpd per foot. The higher values apply to those wells screened in the relatively porous limestone unit of the formation; the lower values pertain to wells screened in the sand facies of the formation. Yields up to 660 gpm have been reported from wells in the McBean formation.

The hydrostatic head of water in the Tuscaloosa formation is about 380 ft above mean sea level on the Aiken Plateau and decreases to 124 ft above mean sea level at Parris Island, on the Atlantic coast. The linear distance between the two points is approximately 100 miles; hence, the average gradient amounts to about 2.5 ft per mile. Thus, if the average transmissibility is assumed as 100,000 gpd per foot, the quantity of water moving through this formation per day per lineal mile (measured at right angles to the direction of flow) is $2.5 \times 100{,}000$, or 250,000 gpd. In Fig. 4 the distance between the 340-ft piezometric contour at Aiken and the 140-ft contour near the Savannah River is approximately 14 miles. The difference in head is about 200 ft; hence the gradient over the distance is about 14 ft per mile. Using a value of 200,000 for the transmissibility of the Tuscaloosa formation in this area, then $200{,}000 \times 14$ or 2.8 mgd of water crosses each 1-mile strip of the aquifer normal to the 140-ft contour line, or, approximately 125 mgd discharges into the Savannah River along the entire length of the 140-ft contour.

In the northeastern part of the coastal plain, the static head of water in the Tuscaloosa formation is about 330 ft above mean sea level at Bethune, in Kershaw County, and the head at St. Stephens, in Berkeley County, is about 130 ft above mean sea level. The distance between these points along the dip of the formation is approximately 70 miles; hence the gradient in this part of the coastal plain amounts to 2.9 ft per mile. Using an average figure of 75,000 gpd per foot for the transmissibility of the Tuscaloosa formation in the entire coastal plain of South Carolina, an average gradient of 2.7 ft per mile, and a straight-line length of 170 miles for the coastal plain in a direction along the strike, then the average quantity of water passing down and discharging through the Tuscaloosa formations amounts to $170 \times 2.7 \times 75{,}000 = 34$ mgd. This is a very rough calculation, and a more accurate figure must be several times this amount, indicating that the assumed value for transmissibility is probably too low.

Fluctuations in Aquifers

Ground water investigations currently in progress in South Carolina include the periodic measurement of continuous recording of water levels in selected observation wells. At present, most of the wells measured are in the coastal plain and reflect water level changes in artesian aquifers. Some reflect water table conditions.

Factors that bring about a change in water level in water table aquifers include any phenomena that cause a recharge or discharge. Precipitation,

topography, evapotranspiration, temperature, and climatic changes, together with pumping and natural ground water drainage, all contribute to changes in water levels. These relationships have been described in detail by numerous investigators, including Thomas (*3*), Jacob (*2*), and Stringfield, Warren, and Cooper (*4*), and the principles involved are applicable to the Atlantic Coastal Plain as well as other areas. In South Carolina, water level fluctuations in water table aquifers can be correlated directly with precipitation during the winter and the cooler months of the spring and autumn. During the hot summer season, however, there is a decline in water levels despite the fact that the rainfall is heaviest during this period. The explanation for this is that the high rate of evapotranspiration prevents much, if any, recharge to the water table reservoir; also, summer rains generally are intense rather than prolonged, so that surface runoff, rather than infiltration, is favored.

Factors that cause water level fluctuations in artesian aquifers are diverse, and, to some extent, complex. Parker and Stringfield (*5*) have described these factors from observations in Florida. They apply equally to water level changes in artesian wells in South Carolina.

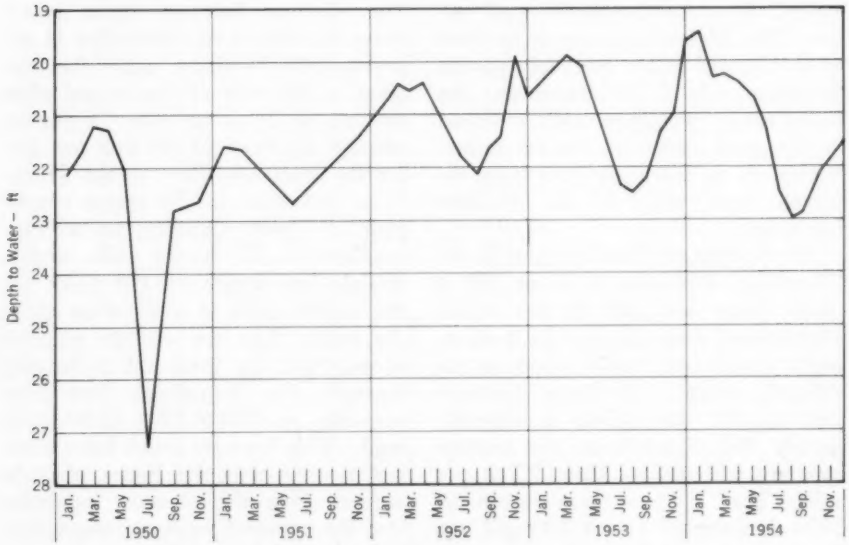

Fig. 6. Hydrograph of Water Level Fluctuations in an Artesian Well

Record of a 900-ft well at Summerville, S.C.

Pumping of nearby wells is one of the principal causes of changes in ground water levels. In artesian aquifers, the effect of pumping has been observed in wells as much as 15 miles from the pumped wells.

Artesian aquifers are elastic and will contract or expand upon the application or release of outside forces. Many

types of loading phenomena, such as ocean or earth tides, changes in stream storage, or passing railroad trains, cause fluctuations in artesian water levels. Fluctuations due to earthquakes have been reported from many parts of the world. A change in barometric pressure also affects the water levels in artesian wells, but its effect is complementary to that caused by a tidal rise. The ratio of the water level fluctuations (in wells) caused by the tidal change to the range of tide observed in the ocean has been expressed as the "tidal efficiency." The ratio of the water level change in the well to that of the barometric change (converted into feet of water) is expressed as the "barometric efficiency." The sum of the barometric efficiency and the tidal efficiency is unity.

Water level changes recorded in artesian wells in South Carolina during the past several years have reflected a typical or normal annual cycle. The water levels are at fairly high stages in January, rising to a maximum during the spring season (late February to April). They then decline to a minimum during late summer and early fall, and recover to their maximum levels again the next spring. Under normal climatic conditions, this cycle is repeated year after year. Fig. 5 is the hydrograph of an artesian well 900 ft deep, located in Summerville, Dorchester County. The cycle is remarkably similar to that observed in water table aquifers in the same area. One possible cause may be that the weight of the water which recharges the water table aquifer during the spring, places a load on the underlying artesian aquifer, compressing it, and, thereby, causing the water level to rise. The opposite condition prevails during the summer, when the water table aquifers become depleted and cause the artesian aquifer to expand, and its water level to decline. Another explanation might be that leakage between the two aquifers causes their water levels to fluctuate similarly, or that an increase in pressure in the recharge area, brought about by infiltrated rainfall, is transmitted 60–90 miles in the coastward direction without any appreciable time lag.

The magnitude of a water level change of this type in the artesian aquifer can be calculated as the product of the tidal efficiency times the porosity times the water level change in the water table aquifer, or $F_a = TE \times P \times F_w$. ($F_a$ represents fluctuation in the artesian aquifer; TE, tidal efficiency; P, porosity of water table aquifer; and F_w, fluctuation in the water table aquifer.)

For example, from Fig. 6, the average change in water level between spring and summer amounts to approximately 2 ft. Most of the artesian wells for which records are available indicate a barometric efficiency of about 30–33 per cent. Thus, with a tidal efficiency of 70 per cent and a porosity of 0.3, an artesian water level change of 2 ft would reflect a water table change of 10 ft. However, if the fluctuations in the artesian aquifer were approximately equal to that in the water table aquifer, this would indicate that the fluctuations were not caused by a loading effect, and would also suggest that the discharge area for the artesian aquifer was the coastal plain.

Chemistry of Aquifer Water

The quality of the ground water in the coastal plain aquifers is suitable for most industrial uses. Water obtained from the shallow aquifers of late Tertiary to Pleistocene age generally is

low in dissolved solids. Water from some parts of the shallow Pamlico (Pleistocene) and Waccamaw (Pliocene) formations has a disagreeable odor caused by hydrogen sulfide, and may also be hard and high in iron content. Shallow water from dune sand along the coast is usually hard and high in chloride, and sometimes has an astringent taste.

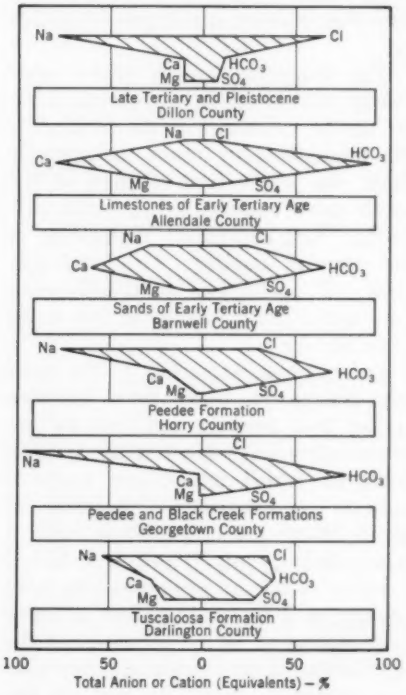

Fig. 7. Chemical Characteristics of Representative Ground Waters From Coastal Plain Aquifers

Centered numeral indicates total solids.

The water in the deeper artesian aquifers is low in dissolved solids near the outcrop areas but becomes more highly mineralized down the dip toward the coast. Despite this increase in dissolved solids, the water in coastal areas becomes softer because of base exchange, in which calcium and magnesium ions are replaced by sodium ions. The result is, typically, a sodium bicarbonate water having a pH of 7.7–8.7. This composition is generally characteristic of waters from aquifers in the Upper Cretaceous, although it applies to some aquifers of Tertiary age, as well. The base-exchange agent or agents have not been definitely identified, but the most likely one is the glauconite, which occurs abundantly in these formations—especially in the Black Creek and Peedee formations. Another base-exchange agent present in coastal plain sediments is the clay mineral montmorillonite, which is reported to have a high capacity for base-exchange action.

Figure 7, based on an adaptation of patterns used by Stiff (6), illustrates the distinctive chemical character of water from the different coastal plain aquifers. On the horizontal axis the patterns show individual elements as percentages of total anions or cations (expressed in equivalents). The dissolved solids content (ppm) is represented as a figure in the center of the pattern. The length of the vertical axis has no significance. The pattern characteristic of water from the Peedee and Black Creek formations is the most uniform. Sodium is always the principal anion. The presence of calcareous beds in the Peedee is reflected in the greater calcium percentage in its water. The water of both formations contains more dissolved solids than that of any other aquifers. It is expected, however, that water from any well tapping the Tuscaloosa formation in coastal areas, similarly, will contain a large amount of dissolved solids.

The patterns for water from limestone, as would be expected, show a predominance of calcium and bicarbonate ions. Water in sands of early Tertiary age, especially those in the western part of the coastal plain, produces a pattern similar to that for limestone aquifers, giving weight to the hypothesis that these sands represent a residuum derived from the decomposition of an original sandy limestone or calcareous sand.

Fluorides

In coastal areas, the fluoride in the artesian water from aquifers in the Upper Cretaceous age is excessive, according to standards recommended by the USPHS for drinking water. The largest amount of fluoride found in water from coastal plain aquifers was 7 ppm. This sample was obtained from the 2,600 to 2,811-ft interval in a well 3,240 ft deep at Parris Island. Subsequent analyses of water from a depth of 2,800 ft in the same well showed only 4.7 ppm of fluoride. The fluoride-bearing water may have come from the Tuscaloosa, the Black Creek, or the Eutaw formation, because the contacts between these units are not definite. The base of the Black Creek is thought to be at approximately 2,400 ft; that of the Eutaw, at about 2,650 ft. The fluoride content decreases in the updip direction, but not as a linear function of the distance from the coast.

The cause of high fluoride in artesian ground water is not known. Some investigators (*7*) have attributed it to the presence of phosphatic deposits, particularly those in the Eutaw formation of Late Cretaceous age. The description of the chemical composition of water in the Eutaw formation in Alabama, as given by Carlston (*7*), corresponds exactly to that of the Black Creek formation in South Carolina. The author has noted the similarity, in both lithology and faunal content, of beds in the Black Creek formation with those of the Eutaw formation in Alabama and Georgia. Stephenson (*1*) identified species of *Ostrea knappi* and *Exogyra upatoiensis* from basal beds of the Black Creek formations in a well at Charleston. Beds of the Eutaw formation have faunal affinities with those in the *Ex. upatoiensis* zone in the Atlantic and Gulf Coast series. Both the Eutaw formation and the Black Creek formation contain large percentages of gray shale, glauconite, phosphate pebbles, pyrite, marcasite, and lignite. The water from both formations is very soft and high in bicarbonate—the bicarbonate content increasing in the down dip direction.

Figure 8 shows the relation between depth of well and fluoride content of the ground water in wells drilled in Conway, Horry County, and the data suggest a linear variation between those factors in this area. Probably, the depth is significant only insofar as it reflects a variance in stratigraphic units. From the data available it appears that the largest amount of fluoride is obtained at depths of 400–450 ft. This suggests that the host bed of the agent causing the high fluoride content lies either within the Peedee formation or at the contact between the Peedee and Black Creek formations. The latter possibility compares with the findings of Carlston (*7*) in Alabama, where the interval responsible for the high fluoride is in the upper part of the Eutaw formation.

The occurrence of fluoride in ground water has been associated by some writers with the presence of volcanic deposits. Mansfield (*8*) indicated the

affinity of phosphates and fluorides during the sedimentary processes and concluded that the major phosphate deposits originated during periods of volcanic activity. Volcanic deposits near the Fall Zone in South Carolina must have supplied some source material for the deposition of the sedimentary beds of the coastal plain and might be a factor explaining the presence of the fluoride. Deposits of topaz, a mineral that contains fluorine, in the western part of Chesterfield County and close to the Fall Line may be a contributing factor.

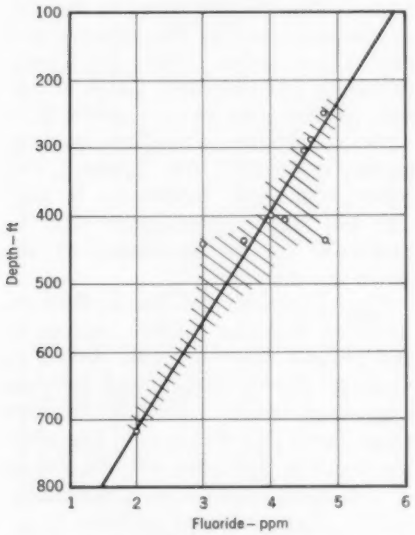

Fig. 8. Relation Between Well Depth and Fluoride Content

Data taken on wells drilled in Conway, S.C.

The presence of glauconite or phosphate minerals alone is not entirely responsible for the fluoride, because some deposits of Tertiary age, that contain either or both of these materials in large quantities, do not contain water high in fluoride.

The correlation between the increase in fluoride and the increase in bicarbonate content suggests a relation between the process of base exchange and that of the solution of fluoride. Time and distance of travel also are significant. As indicated previously by the author (*9*), the occurrence of high fluoride water also has the tendency to be concentrated in those areas and strata which have been recently (in a geologic sense) saturated with sea water—in much the same way that the high chlorides are found in "intrudent" (*10*) water.

Chloride Content

The chloride content of most ground water in the coastal plain is quite low. Water from wells located in the upland counties usually has less than 20 ppm of chloride. In some coastal areas, however, the concentrations are much larger. At least one municipal supply contains chloride in excess of 300 ppm. Greater amounts are present in some aquifers which were impregnated during late Pleistocene or Recent time when the sea stood at higher altitudes than at the present time. Also, in some places, relict seas cut off from circulation with the open ocean provided the environment for the concentration of salts by evaporation. Subsequently these saline waters or residues were covered by sediments and are now included in formations that serve as aquifers. Poor drainage and inadequate time for flushing accounts for the presence of the high-chloride water at the present time. It has also been suggested that some shallow aquifers contain brackish water which originated as deep connate water and rose to the surface along fault zones.

High-chloride water may be found, also, in comparatively shallow artesian aquifers, such as the limestone in the Beaufort area, where the fresh-water head has been reduced sufficiently in some parts of the area to allow salt water (present-day sea water) to move laterally into the aquifer. The sea water has access to the limestone through deep estuaries which serve as natural discharge areas when the fresh-water head is above sea level. This phenomenon conforms with the Ghyben-Herzberg relationship (*11*), which states that the depth to salt water is roughly a function of the height of the water table above mean sea level, and of the density of the sea water. Whenever the head of fresh water is insufficient to maintain equilibrium with that of the salt water in the ocean, the interface between salt water and fresh water will move toward the area of reduced fresh-water head. Deeper parts of the Upper Cretaceous formations also contain brackish or saline waters in wells along the coast. This condition may exist because of a landward encroachment of salt water from a point where the formation is in contact with sea water, due to a lower hydrostatic head of fresh water or it may mean that pockets of connate water still exist at depth, indicating either incomplete flushing or that the fresh water discharges in an upward direction by overriding the brackish water.

The temperature of shallow ground water approximates the mean annual air temperature of the immediate area. The temperature of water occurring within a few tens of feet of the ground surface may vary by as much as a few degrees annually. Deeper water is affected less by surface variations and more by the terrestrial thermal gradient, which is approximately 1°F rise for each 50–100 ft of depth. Ground water temperatures recorded at wells in the South Carolina Coastal Plain range from 62–104°F, and, in all the wells on record, the annual variation is less than 1°F.

Conclusions

Ground water in large quantity and of good quality may be obtained from water table and artesian aquifers throughout the South Carolina Coastal Plain. The water moves through unconsolidated or semiconsolidated beds which range in age from Late Cretaceous to Pleistocene. These occur as wedgelike deposits ranging in total thickness from a feather edge to more than 4,000 ft with a very gentle dip to the south-southeast.

The principal aquifers, in point of potential yield and present use, are those in the Tuscaloosa, Black Creek, and Peedee formations of early Tertiary age. Yields from 8- to 10-in.-gravel-packed wells in these formations amount to more than 2,000 gpm in some areas. The permeabilities of the aquifers vary along both the strike and the dip, generally having highest values in area 20–40 miles downdip from the outcrop.

Out of 45–50 in. of available precipitation, it is estimated that the average surface runoff amounts to approximately 14 in., of which something between 6 and 11 in. represents ground water discharge. The recorded hydrostatic head of water in the Tuscaloosa formation ranges from an altitude of 380 ft in a well near the Fall Line (where the water level is about 150 ft below the general land surface) to 124 ft in a well on the Atlantic Coast, where the head is 114 ft above the land surface. The average gradient of the piezometric surface of the Tuscaloosa

formation is 2.7 ft per mile across the coastal plain.

Factors that cause water levels to change or fluctuate in wells include: topographic location, variations in rainfall, recharge and natural discharge, barometric change, seismic activity; loading phenomena such as tides, surface or ground water storage, and railroad trains; and the factor having the greatest effect—pumping from nearby wells. It is suggested that, in some areas, at least, the annual change in water level in deep artesian wells unaffected by pumping is correlative with seasonal changes in ground water storage, which acts as an application or release of load on the artesian aquifer.

Except for that present in the limestone in the southern part of the coastal plain, most ground water is soft and of excellent chemical quality. The bicarbonate and fluoride content of water in the artesian aquifers increases in the downdip direction and is at a maximum in coastal areas. It is possible that the source of the high fluoride waters in formations of Late Cretaceous age is beds in the Black Creek formation (of Eutaw age) which contain heavy concentrations of glauconite, phosphate pebbles, pyrite, marcasite, siderite, and lignite.

Saline ground water in comparatively shallow aquifers is present because of either incomplete flushing of buried saline waters or because of the reduction in the fresh-water head in the aquifers. Saline water in deep artesian aquifers may be accounted for by the operation of the Ghyben-Herzberg principle or because of incomplete flushing of connate water.

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Automation and the Automatic Valve

William F. End Jr.

A paper presented on Sep. 13, 1956, at the New York Section Meeting, Bolton Landing, N.Y., by William F. End Jr., Plant Mgr., Ross Valve Manufacturing Company, Troy, N.Y.

ALTHOUGH water plant operation formerly depended almost entirely upon manpower, today automatic controls are being widely substituted. With this trend toward automatic control of chemical application, pumping, flow, storage, and pressure has come an increase in the quality of water supplied and an increase in the efficiency of plant operation.

In this period of increasing demand and decreasing supplies, the water plant operator is constantly reminded of the responsibility of improving methods of operation through automation. This discussion covers that aspect of automation which is related to the automatic valve when used in the control of water supply, storage, and distribution—by and with the altitude, float, pressure-reducing, relief, back-pressure, and pump control valves.

A brief description and illustration of each type of automatic valve follows:

1. Altitude and float valves are used primarily to prevent the overflow of elevated tanks, basins, or reservoirs. Figure 1 shows the location of an altitude valve with relation to the elevated tank which it controls. This valve permits flow to the tank for filling and closes to prevent overflow when the water level in the tank has reached its high point. When the pressure at the inlet or distribution side of the valve drops below tank head, the valve opens to allow flow from the tank to distribution.

2. The pressure-reducing valve acts to protect against excessive pressures on the downstream side of the valve. The pressure to which it reduces is adjustable, but remains essentially constant for any changes in rate of flow. Figure 2 shows a pressure-reducing valve passing water from a high-pressure to a low-pressure zone with a reduction in pressure of 140 to 40 psi.

3. The back-pressure valve operates to maintain a fixed pressure at the inlet side of the valve. A back-pressure valve would be used as shown in Fig. 2 to prevent the pressure in the high zone from falling below 140 psi. The valve will, however, permit flow to supplement the supply to the low-pressure zone as long as this high pressure of 140 psi is maintained.

4. The relief valve protects against excessive distribution, supply, or pump pressures by dissipating excess water to waste or to a zone of lower pressure when the preadjusted setting of the valve is reached. In Fig. 3, the relief valves are shown piped in a bypass around each pump to protect against surges by water passing from the discharge to the suction side of each pump. Each relief valve opens when the pressure at the discharge of the pump exceeds the valve setting of 10 psi above the normal pumping pressure.

5. The pump control valve protects against starting and stopping surges of centrifugal and deep-well pumps by means of coordinated and controlled opening and closing speeds. As can be seen in Fig. 4, this valve is located in the discharge line of the deep-well pump rather than in a bypass around the pump as was necessary for the relief valve. Because of its location, this valve performs double duty as a surge arrester and check valve.

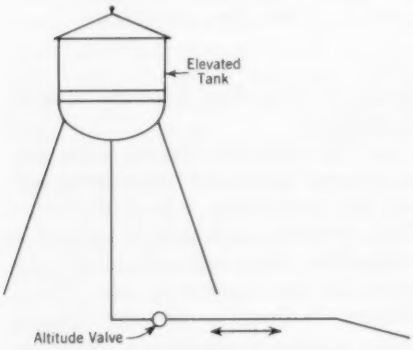


Fig. 1. Typical Location of Altitude Valve

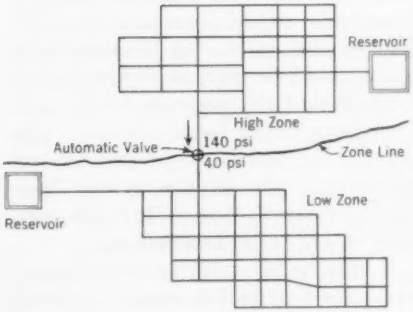


Fig. 2. Location of Back-Pressure Valve in a Distribution System

In this system, valve would operate to prevent pressure in high zone from falling below 140 psi.

Combination Valve

The valves described are basic and essentially have only a single function. Any number of these same automatic functions as well as additional ones (both electric and hydraulic) may be incorporated in one valve for the purpose of satisfying a particular set of hydraulic conditions. This type of automatic valve is called a combination valve and embodies characteristics best fitted to illustrate the concept of automation. Figure 5 is a diagram of a typical installation which employs this type of valve.

The purpose of this installation is to provide a normal, uniform pressure at the far end of a distribution system having a source of supply which is conducive to wide fluctuations in pressure. A tank 115 ft high is used at this point in the distribution system to maintain the pressure during periods of peak consumption. The equipment consists of Check Valve C-1 for flow from the tank when the tank head is above 40 psi, an automatic combination valve to prevent tank overflow and assist in maintaining the distribution pressure between 40 and 50 psi, a pump to boost the distribution pressure when the tank head drops below 40 psi, and Check Valve C-2 to prevent reverse flow through the pump when it is shut down.

Filling of the tank will normally take place through the combination valve during off-peak loads, primarily at night. (The controls required for this and other functions are shown in Fig. 6.) The filling cycle employs Pilot Valves A, B, and S-1 operating in series. Pilot Valve S-1 is a solenoid valve which is de-energized while the pump is not in operation and permits

control by Pilots A and B-1. Pilot Valve A is an altitude control and allows flow through the combination valve to the tank until the tank has filled. Pilot Valve B-1 permits flow to the tank only at times when the distribution pressure is above the required minimum. This valve will, therefore, throttle the combination valve for the purpose of maintaining a minimum distribution pressure of 40 psi during the filling operation. The distribution pressure, however, is capable of exceeding 40 psi and must rise to at least 50 psi in order to fill the tank, which is 115 ft high.

Although only the combination valve is required during the filling operation, for discharge, the check valves and booster pump as well as the combination valve are used to maintain properly the desired distribution pressures.

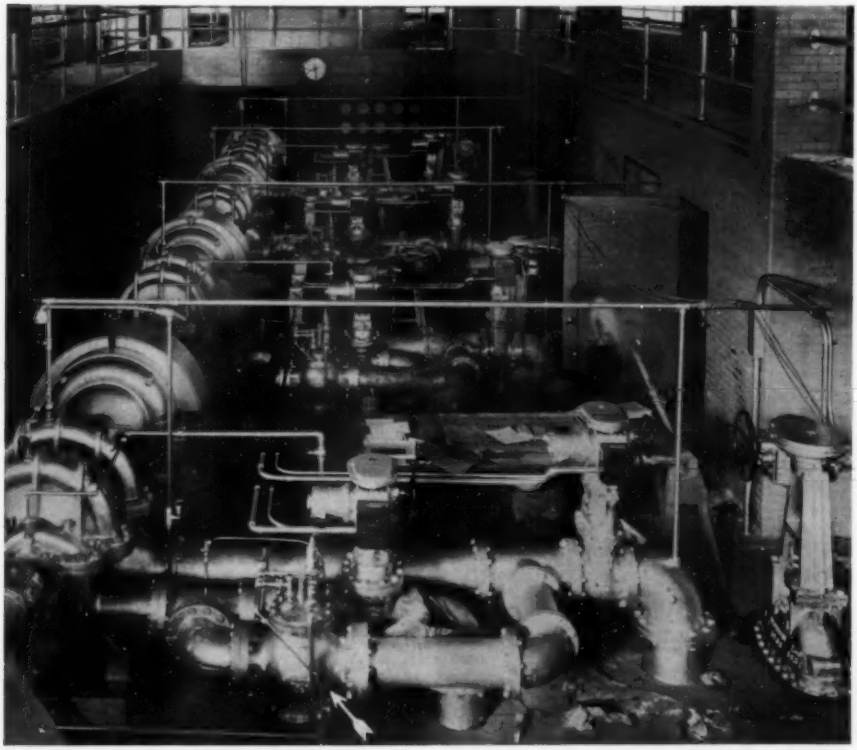


Fig. 3. Relief Valves in a High-Pressure Pumping Station Installation at Coney Island, New York City

Arrow indicates a relief valve in a bypass around a pump.

Initial flow from the tank takes place through Check Valve C-1 when the distribution pressure starts to drop below full tank head—50 psi. This check valve continues to supply the

distribution until the tank head and distribution pressure drop to 40 psi, the minimum allowable pressure. At this point, a pressure switch starts the booster pump which raises the distribution pressure to 46 psi, an arbitrary pumping pressure between 40 and 50 psi.

While the pump is running, the normally open Solenoid Pilot Valve S-1 is energized by the pump circuit and is, therefore, closed. With Solenoid Valve S-1 closed, Altitude Pilot A and Back-Pressure Pilot B-1 are taken out of control. This is necessary since the back pressure pilot B-1 would open the combination valve and allow flow back to the tank, resulting in a drop in distribution pressure to 40 psi. A pressure of 46 psi, however, is now desired.

Fig. 4. A Pump Control Valve Located in the Discharge Line of a Deep-Well Pump

In order to protect against a distribution pressure in excess of 50 psi, Controls B-2 and S-2 are installed in parallel with the other control pilots. Solenoid Pilot Valve S-2 is in the pump circuit, and, when energized, will open rather than close as was the case with Valve S-1. This transfers control of the combination valve to the hydraulic Back-Pressure Pilot Valve B-2.

Pilot B-2 is set to open the combination valve at 50 psi and thereby prevent the distribution pressure from rising above this. There will be, of course, times (with the pump running and source pressure recovered) when the pressure at this point in the system would tend to go above 50 psi. When this occurs, the combination valve will open and allow flow to the tank.

Under these conditions the tank will fill to a height of 93 ft, the equivalent of 40 psi pressure. When this water level is reached in the tank, a pressure switch stops the pump and de-energizes Solenoid Valves S-1 and S-2. Since Solenoid Valve S-1 is normally open, Pilot Valves A and B-1 will again be in control, the tank will float on the line, and the controls on the automatic valve and pump will be in readiness to repeat the cycle.

Although all of the requirements for efficiently supplying make-up water and maintaining a uniform pressure in the system are accomplished, it may be felt that such an installation is too complex and, therefore, impractical. Actually, however, it is merely a combination of simple, individual functions incorporated to obtain the most desirable results.

In essence, the control system described is composed simply of the following individual units linked elec-

trically and hydraulically: an altitude valve; two back-pressure valves; two swing check valves, and a booster pump. Actually only four pieces of equipment are required to perform the work of six, because the altitude and back-pressure functions are incorporated in one automatic valve. This combination valve, operating in conjunction with the auxiliary equipment, produces the desired result of providing uniform pressure throughout the system automatically and with lower initial and operating costs.

Economies in Automation

Automation also assists in increasing the overall efficiency of a water system by reducing costs of installation, operation, and maintenance, and by aiding in the conservation of water.

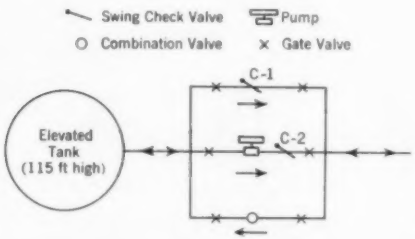


Fig. 5. Diagram of Typical Installation Employing a Combination Valve

None will deny the present high cost of material and labor. If, therefore, use of the automatic valve can result in reduction of the weight and size of pipe, fittings, and valves, the end result would be economy. The pressure-reducing valve, for example, and relief and pump control valves all guard against excessive line pressures and, as a result, would permit the use of lighter weight pipe, valves, and fittings. As for reduction in pipe size or elimination of laying larger main, tanks for peak demand storage, incorporating automatic control in the form of an altitude valve, can be the answer.

Reduction of operating costs can be achieved by automatic valves by reducing labor costs through the elimination of manual operations. The previous descriptions of each type of automatic valve should serve to illustrate the advantages peculiar to each with regard to savings in labor and consequent operating costs.

The same valves—pressure-reducing, relief, and pump control—which guard against excessive line pressures are instrumental in reducing maintenance costs, as pipeline breaks and equipment damage which usually result from high pressures can be avoided by their use. The back-pressure valve also plays an important part in reducing maintenance costs. This is especially true when this valve is used in conjunction with a deep-well pump for the purpose of maintaining back pressure on the pump. Without the valve, an overdrafting might result in heavy damage to both pump and well.

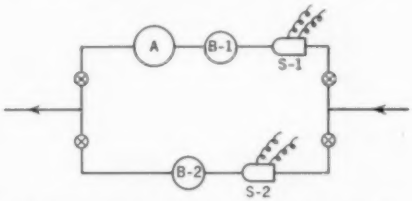


Fig. 6. Controls for the Combination Valve

A is the altitude pilot which closes the valve when the tank is full. B-1 *is a back-pressure pilot set at 40 psi;* S-1 *a normally open solenoid valve;* B-2 *a back-pressure pilot set at 50 psi, and* S-2 *a normally closed solenoid.*

Of equal economic importance with reduced installation, operation, and maintenance costs is economy through

water conservation. In this area, too, automation plays an important role by helping to provide more efficient control of water storage, supply, and distribution. The problem today consists in providing pressures sufficiently low to protect against pipeline and household plumbing failures, together with volumes sufficient to distribute the water properly. In most cases, a pressure of 50 psi will do just as well as 100 psi and, at the same time, result in less water consumption and waste. However, although economy of water usage resulting from lower operating pressures is desirable, provision must also be made to assure that the pressures. The reservoir or source at an elevation of 400 ft supplies two independent distribution systems at different elevations. The primary distribution system is situated between elevations of 250 and 50 ft with pressures ranging from 65 to 151 psi. The secondary distribution system is located between elevations of 375 and 300 ft with a pressure range of 19 to 43 psi.

The most obvious defect in this system is the high pressure of 151 psi in the primary distribution system. This is easily corrected by installing a pressure-reducing valve (shown in Fig. 8) to form a two-zone system. The

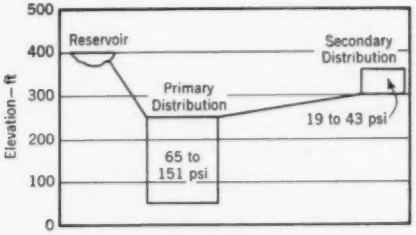


Fig. 7. A Typical Gravity System Without Pressure Regulation

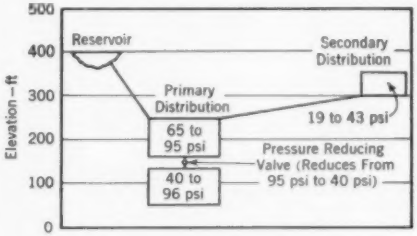


Fig. 8. Gravity System With Pressure Regulation

Unregulated system of Fig. 7 converted to a two-zone system with the addition of a pressure-reducing valve.

sure is maintained at all times for all rates of flow. The automatic valves already described are automatic pressure control valves, and, as such, are capable of furnishing proper distribution at uniform, though relatively low, line pressures. This does not mean that the valves are used merely to reduce excessive pressures. Although this is surely an important function, of equal importance is the function of balancing pressures throughout a system so that each part of the system is provided with sufficient pressure and volume for all requirements.

Typical Installation

Figure 7 shows a typical gravity system with no regulation of pres-

first zone will have static pressures ranging from 65 to 95 psi and the second, static pressures ranging from 40 to 96 psi. For all intents and purposes this may appear to be a satisfactory solution, but there are two other factors to be considered: [1] minimum pressure in the secondary system is too low for adequate fire protection; [2] the pressures in the primary distribution system can be more suitably balanced from the standpoint of water conservation. Figure 9 illustrates how automatic control valves can be used in conjunction with some auxiliary equip-

ment (a booster pump and two storage tanks) to satisfy these deficiencies.

The following changes have now been made:

1. Pressure-reducing valves have been installed to divide the primary distribution into four zones with approximate static pressures ranging from 45 to 66 psi. These pressures are sufficient to satisfy all normal requirements and fire flow.

2. Ground Storage Tank T-1 has been included to supply a booster pump, controlled by pressure switches, combination altitude and back-pressure valve. As an altitude valve it fills and prevents the overflow of Tank T-1. As a back pressure valve, it prevents overdrafting of Zone 1 of the primary distribution system by opening to allow flow to Tank T-1 only when a specific pressure at the inlet side of the combination valve is reached.

The second valve (PCV) is a pump control valve operating in conjunction with and at the discharge of the booster pump. This valve eliminates surges which would be created by

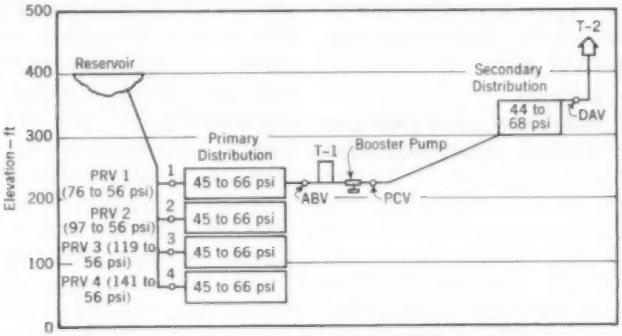


Fig. 9. Typical Applications of Automatic Hydraulic Control Valves in a Distribution System

T *represents a tank;* PCV *a pump control valve;* PRV *a pressure-reducing valve;* ABV *an altitude and back-pressure valve, and* DAV *a double-acting altitude valve.*

which increases the pressures in the secondary system to a range of 44 to 68 psi. The original pressures of 19 to 43 psi were not adequate for fire protection in the high sections of this system. Ground Storage Tank T-2 has been added to supplement the booster pump during periods of heavy consumption and fire flow when the booster pump may empty Tank T-1.

In addition to the auxiliary equipment there are three additional automatic valves. The first (ABV) is a starting and stopping the pump and prevents reversal of flow from the secondary distribution system when the pump is shut down.

The third valve (DAV) is a double acting altitude valve. With this valve, Tank T-2 can be filled during periods of low consumption. When the tank has filled, the altitude valve closes to prevent overflow. With the altitude valve closed, the pressure in the secondary system increases and the high-limit pressure switch at the booster

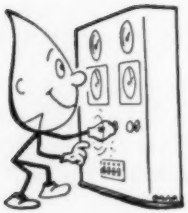
pumping station shuts off the pump. After pump shutdown, the pressure in the secondary system drops and the altitude valve (DAV) opens to feed water from Tank T-2 back to the distribution system. After sufficient storage water has been used, and the pressure in the secondary system has dropped to the setting of the low-limit pressure switch in the booster station, the booster pump starts and storage Tank T-2 refills.

Although the illustration may appear to be elaborate, it does serve to show the many uses and possibilities for automatic hydraulic control valves. The advantages of the system described are that it is:

1. Fully automatic
2. Fully protected against pipe and equipment failures from excessive pressure
3. Fully protected against fire losses arising from insufficient water pressure
4. Designed to provide maximum conservation of water supply through the elimination of water waste from high, unbalanced system pressures.

Conclusion

The problems considered in this paper are typical of those encountered in this age of automation. Automation is no longer merely a word to be used when describing a large, elaborate water system. It is a concept that must be applied to all water systems if they are to be operated efficiently, economically, and with due consideration to conservation of our water supplies.



Treatment of Industrial Water Pollution at Nitro and Charleston, W.Va.

Lawson Haynes

A paper presented on Nov. 1, 1956, at the West Virginia Section Meeting, Bluefield, W.Va., by Lawson Haynes, Supt. of Purification, West Virginia Water Service Company, Charleston, W.Va.

As early as 1930, chemical odors were present in Kanawha River water. Records are available of odor and taste tests made in the Charleston, W.Va. laboratory on samples of Dunbar finished water collected in the fall and early winter of 1930. The city of Dunbar was being supplied by the Kanawha Valley Water Company at Nitro, W.Va., using Kanawha River water as the source of supply. The records indicate the presence of sweet chemical odors which were rated as "'distinct" at room temperature and "decided" when the sample was warmed.

The West Virginia Water Service Company purchased the Nitro water system on Oct. 1, 1934, and, since that time, has engaged in a series of experiments with the purpose of reducing chemical odors in the Kanawha River water. All standard methods of odor control have been tried at the plant or in the laboratory. Ozone was tried on a laboratory scale and found to be ineffective, and a plant-scale test of free residual chlorination had no effect in reducing the odors. Laboratory size filters of active carbon removed all odor and taste from the raw or finished water, but tests showed that the absorptive capacity of the carbon is exhausted so quickly (even on finished water), that it would not be practical to use granular active-carbon filters on a plant scale.

Until late in 1952, when phenolic type odors first appeared in troublesome quantities in Kanawha River water, chlorine dioxide had no effect on the odors in plant scale tests. Since March 1953, chlorine dioxide has been applied continuously to the finished water with beneficial effect on the odor and taste.

Numerous experiments have confirmed the fact that the only practical method of reducing the majority of the odors present is high-pressure aeration through spray nozzles, with powdered active carbon added to reduce the odor further. Experience with carbon doses on a plant scale (as high as 445 ppm—3,700 lb per million gallons) has shown that carbon alone will not successfully control the odor in the river water.

The years 1943–44, 1951–53, and 1955 gave serious difficulty with odors in the river water. In late 1952 and the years 1953 and 1955, taste was also a problem. Table 1 shows a summary of threshold odor numbers observed on the river water from 1943 to 1955, inclusive.

Present Treatment

The present practice at Nitro is to aerate all raw water at a pressure of about 50 psi through spray nozzles. Active carbon is added in amounts of 100–700 lb per million gallons. After filtration, 0.4 ppm chlorine dioxide is

added to the water. An overall odor reduction of close to 90 per cent has been obtained since 1952.

At the Belle, W.Va. filter plant, 26.1 mi above Nitro on the Kanawha River, the water is of excellent quality, and tastes and odors are quite rare. When needed, however, treatment consists of the addition of powdered active carbon to the raw water. Table 2 shows a comparison of the carbon used at the Belle and Nitro plants.

TABLE 1

*Threshold Odor Numbers for Kanawha River Water, 1943–55**

Year	Minimum	Maximum	Average
1943	56	5,000	1,244
1944	21	6,250	1,012
1945	19	3,125	349
1946	4	833	318
1947	4	600	175
1948	2	250	82
1949	1	315	45
1950	2	313	83
1951	19	4,160	384
1952	12	12,500	1,009
1953	60	1,900	399
1954	60	400	142
1955	10	8,000	726

* Determined at Nitro, W.Va.

From the above tables it is clear that the need for active carbon in treating Kanawha River water at Nitro has been increasing year by year; the Belle plant, at the same time, has needed very small amounts of carbon.

Power for operating the aerator at Nitro has been estimated at $10.00 per million gallons of water treated, and the carbon used in 1955 cost an average of $20.44 per million gallons. In addition, 5,210 lb of sodium chlorite was used to produce chlorine dioxide at a cost of $1.97 per million gallons. The total cost for odor control at Nitro in 1955 was $32.41 for each million gallons of water treated.

Fortunately, the condition of the river water in 1956 (with the exception of January) has been improved in odor and taste, as a result of greater flow in the river. Even with improved river conditions, it has been necessary to use 192,215 lb of carbon at the Nitro plant for the first 8 months of this year.

Elk River Water

For many years before July 1949, Elk River water, used by the Charleston plant, at times contained great slugs of odor and taste of a phenolic and oily nature. Since July 1949 there has been no evidence of this type of industrial pollution. The industrial installations on the Elk River have been doing an excellent job of pollution abatement recently and, although mild odors of a type resembling gasoline or oil are common in the colder months, they are not difficult to remove.

In 1952 the flow of the Elk was low for an extended period in the fall. Preparations were completed to withdraw water from a point about 4 mi upriver from the mouth (as far up as Kanawha River backwater reached). This water was then to be pumped to a spray aerator behind a temporary dam, and then to the Charleston filter plant from the Coonskin Pumping Station. At about the time this installation was completed in 1952, the Elk began to flow freely and the installation was not needed.

In 1953, however, the Elk River flow was reduced to almost zero for an extended period. Beginning Sep. 2, water was taken from the Elk and aerated through a spray aerator at about 25-psi pressure. From the mouth of the Elk to the intake of the

aerator pump is a large pool of water, estimated at about a 20-day supply for the Charleston plant. As the drought continued, a larger and larger portion of Kanawha River water was used at the Charleston plant until practically all water used came from the Kanawha.

Samples were taken at the mouth of the Elk regularly and at points up the Elk to the aerator pump intake. A showed 4.0 ppm of ammonia and, as the water worked its way up the Elk, the ammonia increased at the aerator intake with each sampling. Finally, the ammonia level in the raw water entering the Charleston filter reached 4.0 ppm.

In free residual chlorination, the higher the ammonia, the higher must be the chlorine dosage in order to oxi-

TABLE 2

Carbon Used in Taste and Odor Control at Belle and Nitro Plants, 1949–55

Year	Water Treated —*1,000 gal*	Carbon Used		
		lb	*ppm*	Cost —*dollars*
Belle Plant				
1949	209,639	0	—	—
1950	230,794	0	—	—
1951	218,705	1,300	.69	66
1952	237,823	245	.17	13
1953	253,529	1,120	.51	84
1954	273,359	0	—	—
1955	296,664	245	.17	20
Nitro Plant				
1949	1,375,279	85,700	6.85	4,925
1950	1,440,169	159,445	13.70	8,530
1951	1,529,600	186,600	15.41	9,600
1952	1,608,750	201,100	15.41	11,500
1953	1,681,594	270,900	18.83	19,700
1954	1,762,844	274,900	18.83	23,200
1955	1,817,173	450,600	29.10	37,150

strong varnish odor which was always present at the mouth of the Elk, disappeared by the time the water had reached 4 miles upriver and had been aerated. As could be expected, algae growths and odors appeared in the water in the pool. These odors were fairly well controlled by free residual chlorination and carbon.

Every sample of the Kanawha River collected at the mouth of the Elk dize the ammonia. Higher and higher doses of chlorine were applied to maintain breakpoint at the Charleston plant until the limit of chlorination capacity was reached. This occurred on Oct. 12 and, when the ammonia in the raw water had reached 2.8 ppm, the plant was forced off breakpoint. Thereafter, until the end of the drought, the odors present in the raw water could not be controlled as ef-

fectively as previously. On Dec. 5 the drought was completely broken.

Conclusion

Kanawha River water at Nitro is polluted with chemical wastes which are difficult and expensive to treat in the Nitro filter plant. The Belle filter plant, 26.1 miles above Nitro on the Kanawha River, has almost no difficulty with industrial wastes in Kanawha River water.

Since July 1949, the Charleston plant on the Elk River has not been subjected to odor and taste slugs, because of the excellent waste treatment practices of the industries on the Elk. In 1953, the use of Kanawha River water at Charleston showed that this water contained industrial wastes, the most troublesome of which was ammonia.

EDITOR'S NOTE: A comparison of conditions at Nitro in 1956 with those reported by the same author in 1944 (October 1945 issue, p. 1013) certainly indicates that the ingenuity of the author in devising ways to make his raw water supply potable has not diminished over the years. Fortunately there is promise now that the industries which have been taxing his ingenuity will soon institute waste treatment methods that will eliminate the trouble experienced.

Steel Pipe Joint Standards Revised

On Jan. 22, 1957, the AWWA Board of Directors approved the following revisions to Standard Specifications for Field Welding of Steel Water Pipe Joints—AWWA C206–50:

Sec. 8–2—Filler Metal. Change to read:

> Manual arc-welding electrodes shall conform to the requirements of AWS-ASTM Specifications for Mild Steel Arc-Welding Electrodes (AWS designation A5.1; ASTM designation A233), of the latest revision. Electrodes shall be any E60- classification suitable for the electric current characteristics, the position of welding, and other conditions of intended use.

Sec. 8–8.3—Weather Conditions. Add the following sentence at the end of this section:

> (See Sec. 8–8.4 regarding use of low-hydrogen electrodes.)

Insert the following new section and renumber succeeding sections accordingly:

> *Sec. 8–8.4—Low-Hydrogen Electrodes.* The use of low-hydrogen electrodes (E6015 or E6016) will be helpful when welding is performed at low temperatures, especially when welding materials more than 1 in. thick.

The revised specification is redesignated AWWA C206–57.

Water Supply for Large Industries

Robert C. Lewis

A paper presented on Sep. 20, 1956, at the Ohio Section Meeting, by Robert C. Lewis, Gen. Mgr., Southwestern Ohio Water Co., Cincinnati, Ohio.

THIS account relates the experiences encountered in the organization and operation of a water system that supplies water for industrial use only. It is hoped that this record of performance to date will be of help and interest to those who already supply water to industries, and to those who contemplate doing so. The Southwestern Ohio Water Company was incorporated Nov. 1, 1949, to provide constant-temperature water at competitive rates to supplant the ground water from the Millcreek Valley aquifer, which had become critically inadequate. That a group of industries should engage in the trouble and expense of constructing a water system when an excellent supply was already available (from the city of Cincinnati) may seem strange. At the time, however, Cincinnati was not in position to furnish the quantities of water desired and, in addition, it would have been necessary to refrigerate the city's surface water supply during warm months. The industries involved needed a cheap raw water to maintain their competitive position.

Organization

Southwestern, with twelve participant companies, is not organized for profit; it is an entity apart from its participants, but responsible to all. Each member company owns shares in proportion to its water allotment and each has committed itself to purchase from Southwestern a minimum number of gallons of water per day, 365 days per year.

The twelve shareholders elect nine directors for a term of one year, and the directors, in turn, elect the officers of Southwestern: a president, two vice-presidents, a secretary-treasurer, and an assistant secretary-treasurer—the latter office held by the manager. Normal business, including construction and operation, is the manager's responsibility. Special problems are considered by committees which recommend necessary action or policy to the directors. The committees consist of experts from three or more participating industries, so that Southwestern has the advantage of top echelon advice. Committees have been appointed for the areas of finance, engineering, law, accounting, real estate, and purchasing. The engineering committee for example, decides how necessary capacity is to be provided, selects the consulting engineers, reviews plans, approves estimates, and prescribes efficiency tests.

Consultants are engaged by the manager after approval by the appropriate committee and the president, and operating personnel are hired by the manager in accordance with a policy set up by the directors.

The manager reports to the president and works closely with the

secretary-treasurer. Formal report is made by the president to the shareholders at the annual meeting. Directors meetings are held as necessary—but at least once each year. A monthly report of operations and a quarterly financial statement are sent to all shareholders by the manager, together with periodic construction reports.

Operation

Southwestern pumps ground water from the Miami aquifer, south of Ross, Ohio, east 14 miles to a reservoir in the Millcreek Valley from which water is distributed 3 miles north and 7 miles south to plants of the twelve participants. The aquifer, a complex series of glacial deposits, averages 120 ft thick and is bordered by the Miami River. Operations are on a continuous 7-day week basis.

Each participant has agreed that its peak consumption will not exceed 160 per cent of the average daily water usage. In the design of the original system, the question of the maximum composite peak for a small number of customers was considered at length. It was decided to use a "diversity factor" of 90 per cent, or to design for total peaks of 0.9×160 per cent, or 144 per cent. Considering an average industry with a partial or total 2-week summer shutdown, the total actual working days are 52×5, less seven holidays and ten vacation days, or 243 days. Assuming no appreciable water consumption on weekends, vacations, or holidays, the ratio of calendar days to usage days (365:243) is 150 per cent. Experience to date shows that there is sufficient consumption on holidays and weekends to hold 24-hr peaks to 145 per cent of average daily consumption. Saturday and Sunday usage is about 55 per cent of the weekday peaks. Holiday usage, if in the middle of the week, is about 70 per cent of weekday peaks; if either a Friday or Monday, consumption falls to 55 per cent—the weekend average.

There has been agreeably small variation in demand over the 24-hr period on a normal work day. Usage from 7:00 PM to 7:00 AM is normally 90 per cent of that of the daylight hours, and weekend pumping from noon Saturday to 2:00 AM Monday is quite constant. From 2:00 AM Monday to 6:00 AM Monday, the load increases rapidly to a peak which is sustained until midnight Friday and then falls off gradually to noon Saturday. Since industrial water consumption is affected by factors not always apparent in residential water use, such as production variations, materials delivery, strikes, and the general economic picture, it can only be surmised that the diversity of industries, in other than severe recessions, causes sufficient overlapping of peaks and dips to result in a relatively constant demand curve. The situation is unique, too, in that several customers have alternate sources of water. This may result in their maintaining a more constant demand on Southwestern in order to use their water commitments.

The system employs a means of regulating peaks by mechanical controllers located on all original metering installations. These controllers have been set to restrict flows in excess of 180 per cent of allocated average flows, or somewhat above the promised 160 per cent peaks already mentioned. With the exception of two instances, it has not been necessary for the controllers to act, because all customers have flow recorders and are very conscious of their rates of water usage. The accent on water

saving has been evident as the sewerage charges have increased.

The requirement that all Southwestern shareholders commit themselves to specific quantities of water has been advantageous not only to the company, but to its participants as well, for these commitments have been compelling factors in their water planning. Because it is felt that some flexibility of operation is desirable, unused commitments are allowed to accumulate to the end of each fiscal year, when they are cancelled. This procedure leads to the practice of billing customers each month on the basis of accumulated water usage or commitment for the fiscal year (whichever is greater), less water payments to the date of the invoice. No charge is made for high-peak usage nor is credit allowed for high-volume usage. This practice is pursued because the problem of exactly balancing receipts with expenses for each fiscal year in this nonprofit corporation becomes too complex with the introduction of further revenue uncertainties.

Obviously, accumulation of credits through unused commitments encourages higher usage at particular times, but these peaks have not as yet been so high as to cause reconsideration of this policy.

Costs and Billing

At the start of each fiscal year, the manager prepares an estimate of water consumption in that year, together with a detailed budget showing assumed operating costs. Dividing estimated costs by estimated consumption gives an estimated water rate. Water bills are prepared with the estimated cost as a basis of computation. Unless there is a considerable deviation of actual costs or usage or both from the estimated figures, water bills for the first 11 months of a fiscal year are based on the predetermined estimated water rate. At the end of the fiscal year, as soon as the books are closed, the actual water cost is determined on the basis of actual costs and consumption. The final water bill for the preceding fiscal year is then prepared, and contains the necessary adjustments to bring each customer's charges for the end of the fiscal year to the product of the actual consumption or commitment (whichever is greater) and the actual water cost. Obviously, every effort is made to produce a good first estimate. To date it has been fortunate that year end adjustments have been small.

The necessity for operating on an estimated water cost which may have to be adjusted from time to time, stresses the desirability of monthly billings on a cumulative basis for each particular year. It has been found that some industries measure water in units of 100 cu ft and others in units of 1,000 gal. To avoid confusion, consumption and water costs are reported in both systems of units.

With a small number of customers, each of whom takes large quantities of water, it was found desirable to read meters frequently. Although billing is done monthly, meters are read each week. This frequent reading of meters allows the checking of usage rates while operations are still current, the detection of large meter errors, and the comparison of metered pumpage with metered usage. In this way, sizable leaks may be detected, and adjustments of meter errors can be made when necessary.

Pumpage is quite accurately determined for each of the two pumping stations by closely checking venturi

meters, each of which is equipped with a transmitter and remote receiver. A secondary check on pumpage derives from the known pump output in gallons per kilowatt hour per foot of drawdown. Total gallons pumped divided by kilowatt hours of electrical power consumed in the pumping period gives an average in gallons per kilowatt hour which varies only slightly from month to month.

The metered usage figure, adjusted for reservoir variation, is compared to the pumpage. The object is to balance metered usage with pumpage within the 2 per cent variation of the meters. Recent checks have been gratifying; typical are the figures for Aug. 1956: a total of 437.938 mil gal pumped, plus a reservoir gain of 0.981 mil gal gave a net delivered of 436.957 mil gal. Total metered usage was 436.153 mil gal, with meter errors and leakage amounting to 0.804 mil gal, giving an error of 0.54 per cent.

Quality

The varied uses to which the water is put, make it uneconomic for any treatment to be given the water by Southwestern; the individual participants treat it as necessary. Because about 70 per cent of the water is used for cooling, there is concern about the water's temperature, clarity, and chemical properties.

Temperature has been determined by location of two Ranney collectors in the aquifer and the elevation of collector laterals. Table 1 gives a tabulation of temperatures for the months Sep. 1955 to Aug. 1956, inclusive.

Clarity results from the use of ground water that is naturally filtered by the immense sand and gravel deposits. However, it has been found necessary to combat algae in the storage reservoir. This is done by small dosages of chlorine gas plus periodic shock treatments of hypochlorite pellets at troublesome areas. Copper sulfate cannot be used because of its possible adverse influence on industrial plating processes. Current experiments on the effectiveness and economy of two new algicides have produced no results to date.

One customer who takes water from the supply main ahead of the reservoir has been troubled with manganese deposits in a heat exchanger where flows are small and velocities low. This customer has reported a periodic build-up of manganese in the resins of the ion-exchange water softening system. Others, with similar softening systems, but located 10–14 miles downstream and below the reservoir, report

TABLE 1

*Temperature of Miami Aquifer Water for Period Sep. 1955–Aug. 1956**

1955		1956			
Month	°F	Month	°F	Month	°F
Sep.	54.9	Jan.	55.9	May	55.5
Oct.	54.9	Feb.	56.0	Jun.	55.2
Nov.	55.0	Mar.	56.2	Jul.	55.1
Dec.	55.7	Apr.	56.0	Aug.	55.9

no trouble. Tests of water samples from the reservoir show no manganese, although up to 0.2 ppm of manganese was reported in well water samples taken at the same time (Table 2).

A thorough cleaning of the reservoir in late 1955 failed to show appreciable manganese deposits. It appears that the irregular grade of the supply main and its numerous air valves have aerated the water and caused manganese salts to be deposited.

TABLE 2

*Comparison of Levels of Solids and Gases in Water at the Wells and at Reservoir**

Substance	Well No. 1	Well No. 2	Reservoir
pH	7.9	8.1	7.5
Carbon Dioxide	8	3	15
Total alkalinity as $CACO_3$	269	256	271
Hydroxide	0	0	0
Carbonate	0	0	0
Bicarbonate	269	256	271
Total hardness	338.2	312.4	320
Total solids	413	354	378
Silica (SiO_2)	8.8	3.6	1.6
Magnesium	27	25	25
Calcium	91	84	87
Iron and aluminum oxide	2.8	2.8	0
Sulfates	76	73	69
Chlorides	28	21	19
Iron	0.25	0.1	0.1
Manganese	0.2	0.2	None

* All expressed in ppm except pH.

Evaluation

The fact that a definite water delivery for a specified number of years is guaranteed to each customer, that this demand is increasing, and that possible requests for water by new participants must be faced, is responsible for inaugurating a very careful evaluation of the resources of the aquifer in which the wells are located.

A long-term study of the area has been started by the USGS under cooperative agreement between that agency and Hamilton County. In this study, a number of geologic test holes have been driven and a considerably greater number of water level observation wells have been established. Periodic measurements are being made of the water levels, temperature, and quality, both in test wells and significant streams. It is hoped that the factors governing ground water resources in this area can be recognized and evaluated.

There is little fundamental difference between the operations of the Southwestern system and a municipal system. Different types of peak demand occur at different times from domestic requirements, but the basic problem is to furnish water of good quality at the lowest rates consistent with good management, to conserve resources, and to anticipate future demands in time to build for them.

Submerged Aquatic Plants in a Primary Settling Reservoir

William Bridge Cooke, William Marcus Ingram, Alfred F. Bartsch, and J. Daniel Enright

A contribution to the Journal by William Bridge Cooke, William Marcus Ingram, and Alfred F. Bartsch, Biologists with the Water Supply and Water Pollution Program, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio, and J. Daniel Enright, Supervisor of Water Purification, Cincinnati, Ohio.

IN September 1955, when a primary settling reservoir in the Cincinnati Water Purification Plant was being drained for cleaning, extensive growths of a grass-like plant were revealed (Fig. 1). A similar growth was found in a second primary settling reservoir drained in September 1956. The first reservoir had a capacity of 180 mil gal, the second, 200 mil gal. Draining and cleaning are carried out at 4-year intervals.

Reservoir Description

The reservoirs lie in the basins of two small stream systems which have been dammed. Thus, the brick-lined sloping walls form a kind of funnel, at the bottom of which is the outlet used during the cleaning operation. River water which has been chlorinated between the pumping station and the reservoir is pumped into these reservoirs, and the river mud and other components of the sludge are allowed to settle out on the brick floor. This floor is continuous from the bottom of the funnel to the top of the wall around the edge of the reservoir. Water levels are maintained to near the top of the wall, but these may fluctuate because of the differential between pumping and filtration rates.

In September 1955 and again in September 1956 collections were made of the grass-like plant which developed in the mud that had settled out. The plant formed a solid mat for a lineal distance of about 12 ft on the mud on the brick wall from a depth of zero at the water's edge to a depth of about 5 ft. Best growth occurred in the area where the depth of water reached 1–2 ft. There, where water levels apparently fluctuated during the 4-year period between cleaning, the plants attained their maximum development and were able to bloom and develop seeds.

Identification of Species

Specimens of the plants were sent to A. C. Smith, then curator of phanerogams at the Smithsonian Institution, Washington, for identification. He reported that they were of the species *Eleocharis acicularis*. This is one of the common species of spike rush, a member of the sedge family. Fassett (*1*) says: "Needle Rush. Very common on wet shores and in shallow water; Greenland to Alaska, south to Florida, Kentucky, Oklahoma, Wyoming, and Idaho. Frequently sterile. In water this may send up quantities of elongate hair-like stems." Muen-

scher (*2*) adds: "This is a variable species with several varieties." Its widespread distribution is further indicated by its occurrence in Georgia where it was found by Eyles and Robertson (*3*). Fernald (*4*) extended the distribution to New Mexico, California, and Eurasia. The plants found in the Cincinnati reservoirs exhibit few of the unusual peculiarities of the species. The plants, 6–10 in. tall, form an extensive turf-like mat and develop flowers and fruits at the tips of leaf-like culms scattered throughout the mat at 1–2-ft depths. They produce none of the unusual hair-like stems described by Fassett (*1*). Fernald (*4*) indicates that when the plant is submersed it is either dwarfed or develops elongate rhizomes (or less tufted plants which are sometimes more delicate than normal plants). Such growth types were observed only in immature colonies.

The mats formed by the plants were not anchored to the brick walls or between the bricks so that as the water level was lowered in the cleaning process the mat could easily slide down the walls of the reservoir (Fig. 2). This sliding process is speeded up, in cleaning, by flushing the walls with fire hoses mounted on special "bucks." Five bucks manned by crews of three men each are used. Depending on the rapidity of the flushing operation and the work load, all five sets may be in used at one time. In the past, scrapers and brooms were used to keep the sludge moving down the walls, but now, as it accumulates near the bottom of the reservoir under pressure from the hoses, it is handled with a tractor equipped with a blade or "pusher." The sludge is kept wet so that it tends not to clog the drain. Including sludge removal, cleaning and routine maintenance requires 30 days.

Fig. 1. Needle Rush Growing on Wall of Settling Basin

In addition to the spike rush, a grass not in flowering condition was found occasionally in the turf at the margin of the reservoir in 1956. This plant was not associated with any nuisance conditions in further steps of water treatment. Although interference with reservoir cleaning operations was anticipated, no clogging of the drain used in the cleaning operation was experienced.

Fig. 2. Flushing Needle Rush From Wall

The needle rush mat appears as light areas against the mud in the background.

This was true even though the mats broke loose and moved in relatively large masses.

No odors and tastes were associated with this growth. Such growths in reservoirs can serve as catchment areas for some proportion of sediments in water that might otherwise be carried through into coagulation basins. Through photosynthetic activity they can add oxygen to water, as do algae, during daylight hours. Although the sedge or spike rush has no poisonous qualities, it may serve as a place where organisms can lodge, grow, and reproduce. Such organisms could include protozoans, nematodes, bacteria, fungi, and algae.

No records are available to indicate when the sedge first began to grow after the reservoirs had been cleaned. It was observed, however, that some mats had started to develop before September 1956 in the reservoir which had been cleaned in September 1955. Such plants were small and referable without critical observation to the dwarf variety described by Fernald (*4*), and were in the first 2 lineal feet on the brick wall below the normal high-water line so that they are completely submerged at least part of the year. It was evident, however, that in a 4-year period, plants had accumulated to such an extent that they formed a ribbon around the shallower part of the reservoir floor.

Influence on Treatment

During this period of growth, normal chlorine application varied 40–80 lb per million gallons. Efforts are made to keep the chlorine residual (in the water leaving the reservoir) at an average of 0.5 ppm. Residual chlorine, however, varies, at times, from 0.2 ppm to 0.7 and 0.8 ppm. On rare occasions it has reached 1.0 ppm. Alum dosages, when used, varied 45–180 lb per million gallons. The lack of plants in the thicker sludges at the intake pipe of the reservoir indicates that the current of the intake stream is too strong to permit development of the mat, the chlorine application is too concentrated at this point, or that a combination of these two factors is in operation.

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A Water Supply for Suburban Cincinnati

Harold H. Mace

A paper presented on Sep. 19, 1956, at the Ohio Section Meeting, Toledo, Ohio, by Harold H. Mace, Cons. Engr., Cincinnati, Ohio.

THE rapid growth and development experienced in suburban and fringe areas adjacent to metropolitan centers have created an urgent demand for public water supplies. Many municipal water systems have been extended to such areas by the municipality or through county legal procedures. Several independent supplies have been built and still more are needed. The design, construction, financing, and operation of such systems present many real problems to engineers and water works personnel. This paper presents some of the salient features and problems encountered in the recently constructed water system in Clermont County, Ohio.

Clermont County

Clermont County is located in southwestern Ohio immediately east of populous Hamilton County and the city of Cincinnati. Generally speaking, it is a rural agricultural county; however, a rapid change is taking place. Several of the villages in the county have water systems—such as Milford, Williamsburg, Loveland, New Richmond, Batavia, and Bethel. That portion of the county immediately adjacent to Hamilton County and along the two main trunk highways (Routes 74 and 125 leading from Cincinnati) has developed at a phenomenal rate since the late 1940's. It is really an integral part of the greater Cincinnati metropolitan area. The village of Amelia is located within this area at its eastern edge. The population of the three townships involved increased 50 per cent from 1940 to 1950. Studies and house counts made during the course of the survey showed an increase in population of approximately 68 per cent from 1950 to 1954. This growth occurred in spite of the lack of adequate water and sewerage facilities.

Ground water supply within the area is practically nonexistent for individual home supply, let alone a public supply. The area is located on a relatively flat tableland several hundred feet above the Ohio River. Substrata formations consist of alternate layers of clay or shale and limestone below a shallow depth of topsoil. Geologically this is known as the Richmond-Maysville Formation. It is recognized that this formation does not produce ground water in any quantity. A few of the homes, however, did obtain water from shallow wells, but with the growth and development in the area it became virtually impossible to secure sufficient water in this manner—at least on a year-round basis. By far the majority of the residents were forced to have water hauled from nearby communities to supplement their individual well and cistern supplies. The villages of Batavia, Milford and New Richmond sold 7, 8, and 6 mil gal of water, respectively, to tank truckers in 1955. It is not known exactly how much of this water was delivered in the district, but a good percentage actually was consumed in the area.

The principal obstacle to the construction of new water systems in virgin territory is the cost as reflected in the final water rate schedules. The system under consideration was no exception. This may appear paradoxical when it is considered that the minimum charge for water is $7 per month. Actually this is not a high rate unless considered relative to rates in effect on existing systems. It seems that, generally, because of increased construction and operating costs, the thinking on water rates and charges will have to be modified to accept rates higher than have been customary.

Conditions

The conditions compelling raised rates, as well as the procedures followed in the development of the program, may be of interest. The first of these was the cost of hauled water in the area, which, prior to the development of the system, cost anywhere from $3 to $8 per 1,000 gal, depending upon the distance hauled—5 to 15 miles. Some residents paid as high as $150 annually for water. The average cost was about $80 per year. In this connection it must be remembered that even at these costs only a limited supply was used or available, and no fire protection was provided. Further, there was an additional cost for electricity to pump the water to proper pressures for home use. Water was at a premium; it was cheaper to buy beer.

Development in the area has been of the community type—that is, several centers with a fairly heavy population density existed in the area. Undeveloped low-density areas between these communities presented a problem in that it was necessary to construct several miles of unproductive (from the cost and revenue standpoints) water distribution mains in order to obtain proper flow, circulation, and supply to and within the various communities.

Preliminary studies and computations made to determine the cost and economic feasibility of proceeding indicated that a system could be constructed and financed by the issuance of revenue bonds if 40 consumers per mile of water main built, who were willing to pay a minimum charge of $7.25 per month for water, could be secured. When the final costs were in, it was found that this minimum charge could be reduced to $7.00 per month. These data, together with preliminary general plans, were submitted to the county commissioners and were approved. Following this step a campaign was initiated by the civic organizations in the area to secure contracts from the residents agreeing to take water and to pay the rate stated.

The results of this campaign were very gratifying. Contracts were signed by 2,300 users out of a total potential of 2,900 homes in the three townships. Unfortunately, many of these signers were beyond the limits where they could be economically served within the established criteria of 40 users per mile. The project, as finally developed in May 1954, proposed service for 1,850 of the signers. This date and the number of signers are significant because on Aug. 31, 1956 (6 months after the system began operation), 2,353 users were connected to the system. This illustrates the growth within the district and the potential of water supply facilities in suburban areas. It indicates that the people are willing to pay for water at rates commensurate with actual costs. The project was put into service on Feb. 1, 1956.

Design criteria normally used and considered acceptable were modified in

some respects to meet the conditions imposed and to keep initial costs at a minimum. No compromise was made in estimating per capita use. The normal figure of 100 gpcd was employed, and the initially constructed facilities were sized to serve 3,000 water users, or a population of 10,000. This allows for a 62.5 per cent increase in the 1,850 contract signers.

Construction and Design

The following data on the facilities constructed and the design basis or capacity will give some idea of the nature and scope of the project. The area within the district is approximately 32 square miles. The water supply is secured from three gravel packed 16 × 30-in. wells located along the bank of the Ohio River some 5 air miles from the center of the district. The wells are about 90 ft deep in rather fine water-producing sand. They are equipped with 350 gpm pumps, and one well is used for standby service. This site was selected because it was the closest underground supply available and because an alternate ample surface supply is available from the river in case of failure or depletion of the well supply. The well field site is frequently flooded and, to provide for operation during floods, the motors were placed on platforms some 25 ft above ground, which places them above the maximum flood on record. Remote operation of the pumps from the treatment plant is provided. The well casings were extended above-ground inside a 48-in. corrugated-iron encasing pipe. This enclosing pipe was set on a concrete base and the annular space between it and the well casing was filled with concrete to provide stability and mass for the structure.

The well water is pumped to a conventional iron-removal plant about 1 mile from the wells and above maximum flood level. The raw water contains 0.5 ppm iron. The hardness varies from 225 to 325 ppm, depending on the season. The character of the water varies in a more or less direct ratio to the river water, with a 2–3 month lag. The treatment plant as built has a nominal capacity of 1 mgd and consists of an aerator; a plain settling tank, providing a detention period of 2.5 hours at rate capacity, a 1-mgd standard, center-gullet type of filter; a chlorinator; and high-service pumping facilities. Office and laboratory facilities also were provided. Two 700-gpm high-service pumps pump the treated water to a 1-mil gal steel reservoir located at the edge of the district served, from which point it is repumped to the distribution system. Filter washing is accomplished by means of a wash water pump. An 85,000-gal clear well is located beneath the filter and the pump room. Vertical-type turbine pumps are utilized. Chlorination is arranged to permit either pre- or postchlorination.

The plant was laid out to allow for future installation of softening facilities or conversion to a purification plant in the event a surface supply becomes necessary. This would permit expansion to an ultimate capacity of 4 mgd without serious or extensive changes in arrangement. The plant is so located that the future supply line to the reservoir, which will be needed to supplement the present single 12-in. line to meet increased demands, will provide proper protection and insurance of supply in the event of a main break, and, at the same time, will provide water service to users along the route. Ultimately a two-pressure system will be in operation.

A booster pumping station is located immediately adjacent to the 1-mil gal

steel reservoir. Water is pumped from this point to the distribution system. The station is equipped with two 700-gpm pumps. Positive suction head is provided for the pumps from the reservoir. This station is operated automatically; telemetered water levels transmitted to the station from the elevated storage tanks operate the pumps automatically to maintain proper pressure and supply in the system.

The distribution system was laid out to serve the original 1,850 signers. Main sizes were based upon a concurrent fire and an average domestic flow of 500 and 700 gpm respectively, to secure a residual pressure of not less than 20 psi at the fire plug. Normal pressures will vary from 45 to 75 psi, depending on location and elevation. It was recognized that a distribution system could not be provided to meet estimated 20-year needs and stay within the cost limitations. Hence, design flows were adopted to meet estimated consumption by committed customers plus a 62.5 per cent increase. It was estimated that the flow would be reached in about 10 years.

Approximately 55 miles of water mains varying from 6 to 12 in. were required, including raw water and supply lines. A 4-in. paralleling service line was installed through the village of Amelia to reduce the number of street crossings in a recently completed highway improvement. Forty-seven miles of distribution mains were constructed as a part of the first contract to serve the 1,850 users, and 39 users per mile were thus assured. Before the construction was completed, 371 additional applications were received, some of which were located along mains under contract. Many, however, were on streets not proposed to be served. An analysis was made of the situation and it was found that there was ample justification for adding 8.5 miles of distribution main to the system to serve these customers. With this addition, a net of 40 users per mile was assured.

It is interesting to note that many applications and signed contracts have been received since the project was completed. These are for extensions and additions to the system. Further, several lines have been built privately for service in new subdivisions and at no cost to the county. Some 5 miles of main have been built in this manner. At the moment, it appears that the installation of 10 more miles of distribution main can be justified. This would make a total of more than 70 miles of main in the distribution system.

Two 100,000-gal tanks were constructed, and space is provided at each site for additional storage capacity as it is needed and as funds become available.

A small, modern, air-conditioned office building was constructed near the center of the district. It was completely furnished, including a billing machine and mailing equipment. Space is provided in this building for administrative personnel and general office operation personnel, including a billing clerk, clerk-stenographer, and a cashier, and for meter and miscellaneous repairs and meter testing.

Cost of Project

The total cost of the project was $2,770,000 or about $1,250 per connection. The project was financed by the issuance of 4 per cent, 40-year revenue bonds. No bonds will be retired during the first 4 years. Procedures were followed as prescribed by the so-called county sewer district law. A single district was established embracing the entire county, exclusive of incorporated municipalities.

Water rates are as follows. The first 4,000 gal per month, $1.75 per 1,000 gal; the next 4,000 gal per month, $0.60 per 1,000 gal; and more than 8,000 gal per month, $0.50 per 1,000 gal. Minimum monthly charges have been established based upon meter size. The minimum for a ¾-in. meter is $7.00 per month.

After 6 months of operation, no particular problems have arisen except for several main breaks and a minor leakage problem on service lines. This apparently has been eliminated with the repairs of the leaks and the proper flaring of the copper service pipe at the couplings and corporation stops where the leaks occurred.

Financially, the situation seems good. Based on August 1956 data, revenues have reached a rate equal to that estimated for the end of the first full year's operation. Operating costs have exceeded the estimates slightly. Table 1 shows the estimated operating cost compared to the same items of expense as taken from the August data and projected to an annual basis.

Amortization costs will average $143,000 annually over the life of the bond issue. Interest payments during the first 4 years, however, will be only $120,000 annually. With a total annual revenue of $240,000 and an annual operating cost of $45,000 (based upon projection of the August 1956 revenues and expense) there will be available $195,000 to meet the interest payments. A surplus already is assured, and growth of the area, which experience to date indicates will be at a more rapid rate than that originally estimated, will improve and firmly establish the financial soundness of the venture. There seems no question at this point but that funds will be available to meet the expenses of additions, improvements, and enlargements as they are needed.

Summary

Experience with this project seems to indicate that the construction of complete water systems in small communities and suburban areas is possible and feasible, but that water rates will be comparatively higher in such areas because of the relatively high financing and operating costs for a complete system. In such projects many problems arise which require careful analysis and procedure. The real problem, of course, is one of cost. Charges must be kept within the ability of the people to pay, and sufficient customers to produce the revenue required must be assured. Designs must be on a reasonable minimum basis to keep the installation and financing charges down. Likewise, operating personnel are charged with the responsibility of keeping operating costs at as low a level as possible, consistent with providing adequate service.

TABLE 1

Comparison of Original Estimated Costs and Projected Annual Costs

Item	Original Estimated Annual Cost	Projected Annual Cost
Labor	$28,000	$27,400
Power and telephone	8,000	12,300
Miscellaneous office and equipment	1,500	3,000
Transportation	1,100	850
Plant operation and maintenance	1,000	300
Distribution maintenance	1,200	600
Insurance and miscellaneous	1,500	550
Total	$42,300	$45,000

Value of Sludge Calcining

Fred Krause

A paper presented on Sep. 16, 1955, at the Michigan Section Meeting, Flint, Mich., by Fred Krause, Board of Water & Electric Light Comrs., Lansing, Mich. Publication was postponed to permit later operating data.

AN evaluation of any sludge reburning problem should start with an analysis of the sludge and a determination of its value for reburning. A satisfactory finished lime necessarily begins with sludge that is a relatively pure form of calcium carbonate or can be readily processed to a high state of purity.

Quality of Sludge

When surface water of high silica and clay content is softened, the sludge produced will have a concentration of these substances. Because there is no known way of economically separating these impurities, such sludges would have little value for reburning. This means that during some periods plants treating surface waters would be forced to dispose of sludge in some other fashion. A way to prevent sludge contamination is by settling and clarification prior to softening.

Sludge with high magnesium content can be treated both by changes of pH and mechanical separations by centrifuge. Depending on the calcium carbonate–magnesium hydroxide ratio, such sludges can usually be processed to produce an acceptable lime.

The most favorable sludge for reburning results when the softening is preferential and the sludge consists of pure calcium carbonate. But even then, though the sludge is chemically pure and will produce an excellent lime, a pure precipitated calcium carbonate slurry is difficult to handle because it will harden in storage basins and become difficult to repulp.

Reburning Processes

The most popular method of reclaiming calcium carbonate to date is that in which the carbonate is burned to the oxide in rotary kilns. The end product in this case has the physical character of a soft pebble.

Suspension burning and collection of the quicklime as a fine powder is also practiced.

The process * employed at Lansing, Mich., is diagrammed in Fig. 1. Sludge from the water conditioning plant enters the process at the carbonator at concentrations of 10–16 per cent solids. After carbonation with waste gases, the sludge is joined by scrubber water and this mixture goes to the thickener, a multitray unit which thickens the sludge to 20–25 per cent solids. From the thickener, the sludge is pumped to the centrifuge, where the solids are separated and dewatered to a slurry of about 65 per cent solids and the magnesium content is reduced 40 to 65 per cent, depending on operating conditions.

Because the cake from the centrifuge is very sticky, portions of previously dried material are mixed in at this

* The FluoSolids process, a trade name of the Dorr-Oliver Inc., Stamford, Conn., is used.

point until the mix has the appearance of the lumps and dry power found in good pie dough. It can then be more easily handled. Soda ash, whose function will be detailed later, is also added.

After this conditioning, the sludge is dropped into the waste-gas stream from the reactor at the entrance to the cage mill. The cage mill, which is a cross between an impact mill and a fan, breaks up the lumps and disperses the solids in the gas stream for practically instantaneous drying. A cyclone removes the solids from the gases and the gases are sent to a scrubber for water cleaning before being exhausted to atmosphere. Solids collected by the cyclone are divided, with a portion going back for remix and the remainder going to a dried-sludge storage bin. The dried sludge is picked up by an air stream and is blown into the calcining compartment of the reactor.

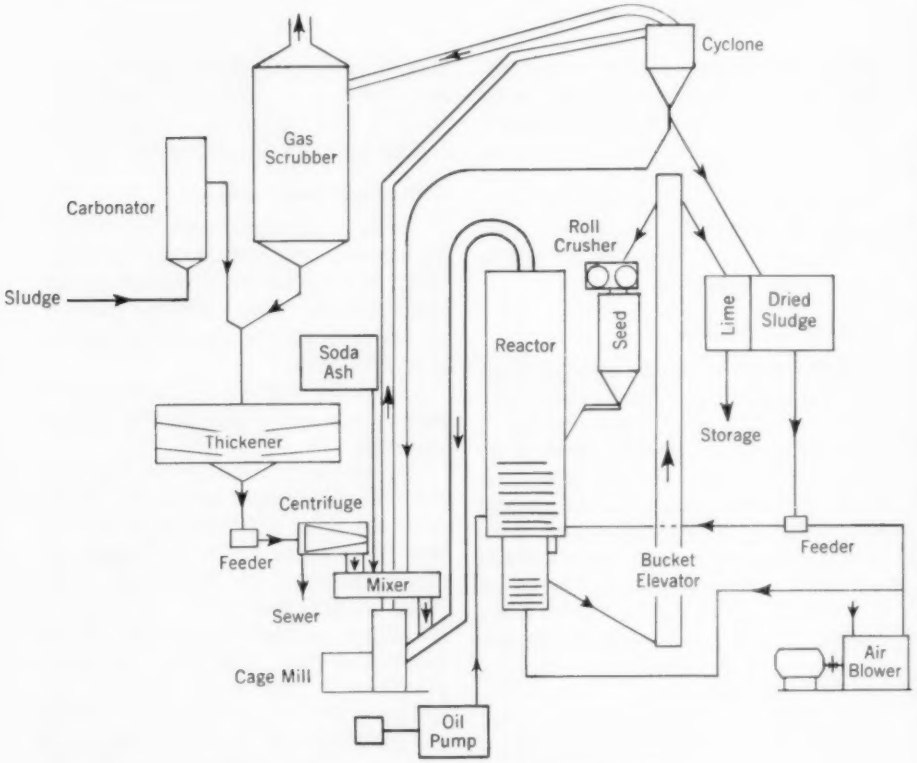


Fig. 1. Flow Diagram of Lime Sludge Calciner

This process is used at the Lansing, Mich., plant.

The reactor is a vertical furnace divided horizontally into two unequal portions by a perforated-plate arch. Air enters the lower or cooling portion

of the furnace and passes through previously burned material, which it cools to approximately 400°F. The air incidentally recovers heat during this process.

The preheated air then passes through the perforated plate into the calcining or burning compartment, where oil is introduced to furnish the heat required for production of lime. Suspended on this burning air stream is a bed consisting of a 6-ft depth of pellets or burned lime particles. As the predried calcium carbonate and soda ash mixture is introduced into the bottom of this fluid bed of particles, the soda ash melts and forms a sticky adhesive. Because of its particle size, the calcium carbonate calcines almost instantly and is trapped by the sticky molten soda ash so that it is caused to adhere to the particles already present, building them up layer upon layer. As this build-up of particles increases the bed depth, some of the pellets are withdrawn and dropped to the cooling compartment where they preheat the incoming combustion air and are themselves cooled from 1,700°F to 400°F.

After cooling, the pellets go into a bucket elevator, which delivers them either to the lime storage bin or to roll crushers. Because buildup in the reactor only occurs on particles already present, new particles must be introduced to replace those that have been removed. The roll crushers, therefore, crush the pellets and feed them back into the reactor.

TABLE 1

Actual and Estimated Costs of Lime Production in Plants of Various Sizes

Item	Amount
Maintenance	5% of equipment cost
20-yr amortization	5% of plant cost
Labor, 32 hr per day	$2.50/hr
Fuel	8.5¢/gal
Electricity	1¢/kwhr
Water	$50/mil gal
Soda ash	$30/ton
Supplies	1% of equipment cost
Supervision	50% of one man's salary

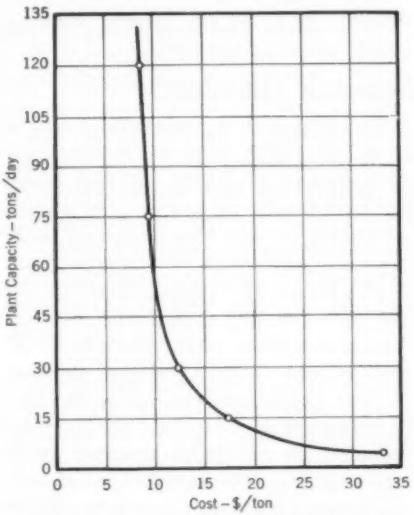


Fig. 2. Costs of Lime Production at Various Capacities

The cost of lime per ton is shown in relation to the daily output. The figures were determined from the actual and estimated costs shown in Table 1.

Costs

Figure 2 shows the expected cost of lime per ton when this process is used in plants of various sizes. From this chart, a plant can roughly determine whether or not sludge burning would be profitable. If the cost per ton of the plant's average daily lime consumption is added to the prorated cost of sludge disposal, and this total lies to the right of the curve at the given rate of consumption for the plant, as

shown on the plant capacity scale, sludge reburning might be a profitable venture. These are only rough indications, however, and each case must be properly investigated and evaluated on its own merits. If a plant has a very severe disposal problem, for instance, sludge reburning might be considered without too much concern about balancing the costs.

Operating Difficulties

In addition to the operating costs, a plant must also consider its expected demand curve and its growth curve for the next 10–20 years. The sludge reburning process does not lend itself to wide variations in rate without large changes in economy and equally difficult operating problems. For instance, if a plant with a capacity of 30 tons per day were to be built, the cost of lime would be expected to be near $12.50 per ton. Should this plant be operated 10 months of the year at 15 tons per day, however, the actual cost of lime produced would be near $17.50 per ton. Moreover, the problems of the operator would be severe.

One of the characteristics of the process is that a sufficient air stream must always be maintained in the reactor to keep the solid particles in suspension. Heating the air and allowing for radiation losses requires an amount of heat at least equal to that absorbed during calcining at the maximum rate of the furnace. Because the maintenance of temperatures in the furnace amounts to 50 per cent or more of capacity fuel cost, proper sizing and operating of plants is very important.

Another operating problem concerns furnace temperatures. When there is a full load in the furnace, the drying of wet cake dissipates the heat. With no load in the furnace, however, there is still 80 per cent as much heat to dissipate, but without material in the drying system to utilize it.

Another characteristic is that the process does not lend itself to intermittent operation such as 16 hr of use and 8 hr of shutdown. Both startup and shutdown periods must be relatively long.

All of these features must be considered before adopting a process of sludge reburning. For those plants which can use it, however, the process can profitably solve a difficult disposal problem.

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1956

A report of the activities of the Committee on Water Works Administration for the year ending Dec. 31, 1956, submitted to the AWWA Board of Directors on Jan. 28, 1957, by Wendell R. LaDue, Chairman.

AS outlined on pages 45–46 of the 1955 AWWA *Directory* (Reference Edition), the present organization of the coordinating committee on Water Works Administration provides for 29 subcommittees grouped in four classifications, with over 120 members of the Association participating. The general committee consists of the chairman, the general chairmen of the four groups, and the chairmen of the various active subcommittees. Committee work has been broadened by the creation of "task groups" subordinate to standing committees. The chairman of a task group is not a member of the Committee on Water Works Administration, but, in general, works within the province of the division under which the task group functions. When the work of a task group covers activities in various divisions, however, the chairman becomes a member of the committee. The present committee personnel is:

W. R. LaDue, *Chairman*

L. S. Finch	M. P. Hatcher
L. E. Ayres	H. E. Hudson Jr.
J. J. Barr	A. P. Kuranz
E. L. Bean	R. J. McLeod
E. S. Cole	R. S. Millar
J. G. Copley	J. H. Murdoch Jr.
M. B. Cunningham	L. N. Thompson
E. L. Filby	A. A. Ulrich
	W. V. Weir

R. J. Faust, *Ex Officio*

At the May 1956 meeting of the board at St. Louis, the following communication from Ned H. Dearborn, President of the National Safety Council, noting that AWWA had been voted National Safety Council Public Interest Award for 1955, was read into the record:

It is a real pleasure for me to inform you that your organization has been voted the National Safety Council Public Interest Award for 1955.

We here at the council, have been well aware of all you have been doing for safety and we are delighted that the judges agreed. I am enclosing a copy of our news release announcing the awards so that you may have a complete list of recipients. You will notice that the story is for release May 3, 1956, so this letter is confidential until that time.

As you know, the award is not competitive. It is designed to allow us to express in tangible form our appreciation for exceptional service to safety.

I am sure you feel as we do, that there is another less tangible result of your safety effort—the knowledge that you have helped prevent many accidents.

Many thanks for your splendid support.

This is a real tribute to the excellent output of the Committee on Safety Practices.

Inactive Subcommittees

The following subcommittees are now inactive or have not been activated:

4110M—Constitutional and Statutory Aspects of Municipal Water Works Organizations

4150M—Taxation and Revenue Allocation (task group active)

4220M—Management Relations.

4230M—Compensation of Water Works Personnel

4310M—Construction Equipment and Material Contracts

4320M—Valuation and Depreciation.

4330M—Cost Trends

4410M—Water Department Reports (advisor retained)

1956 Conference

At the 1956 Conference, at least sixteen principal topics stemming from the committee's activities, either directly or indirectly, were presented at the various sessions. Attendance was good and member interest was unusually high. In fact, the open session of the Committee on Water Works Administration attracted one of the longest attendances of the conference.

Subcommittee Activities

The continuing and growing importance of the diversified phases of water works management and administration is evidenced by the steady flow of inquiries into AWWA headquarters regarding committee activities. These inquiries indicate a need for studied, increased, and continuing activity in all phases of the committee's present field of endeavor and expansion into other fields, as the AWWA program, personnel, and budget will permit, and as the membership requires.

The following is a brief summary of the activities of the several subcommittees during the year 1956:

4120M—Radio and Mobile Communication Facilities for Water Works. Committee activity this year has been in support of a survey which was made through Secretary Jordan's office. Information was obtained from a questionnaire to the water works industry for use by the National Committee for Utilities Radio. This report was used particularly in connection with a hearing before the Federal Communications Commission, Docket 11435, on the application for communications from common carriers having construction and maintenance requirements to use Power Radio Service within the channels previously assigned Power Radio (152–162 megacycle band) and then the 25–50 megacycle band.

This matter has been heard by the FCC and, on Oct. 25, it issued a stay order on the report in Docket 11435 and set the matter for rehearing as requested by NCUR. The NCUR has petitioned the commission for the use of tone signaling for control purposes.

The FCC issued rules and regulations pertaining to "Conelrad" which apply to all licensees in the Power Radio Service. The FCC is preparing a manual for the licensees, outlining procedures and responsibilities for making provisions to receive the Conelrad radio "alert" and "all clear." It is important that each licensee obtain copies of the FCC Regulations, effective Jan. 2, 1957, in order to comply with them.

B. A. Currie, chairman of the Frequency Coordination Subcommittee, NCUR, is conducting a postcard survey at the present time, asking each user of mobile radio to indicate the additional radio channel requirements over the next 10 years. The most important contribution AWWA can make to this committee would be continued

support in working more closely with NCUR.

Secretary Harry Jordan has mailed out appointments for AWWA personnel who are encouraged to attend the Regional Utilities Radio Committee meetings, and attended the annual meeting of NCUR himself. It is recommended that AWWA have a representative at this annual meeting.

4130M—Water Use in Air Conditioning and Other Refrigeration. This committee has been actively engaged in studying continuing problems. The industry is expanding so explosively that it now affects, or will soon materially affect, practically every water works in the country in such approaches as expanding costs, rate structures, water conservation, regulatory methods, tariffs, and legal phases. A questionnaire covering such items has been prepared by the committee and processed for mailing by the AWWA staff. The study and interpretation of the replies will do much toward a better understanding of the real import of the problem and its acceptance as a continuing and potent demand.

4140M—Water Use in Fire Prevention and Protection. As a result of the meetings of this committee there was developed a general review of data required by the National Board of Fire Underwriters, and a continuing program, embracing rate classifications, evaluation, and coverage. The committee was advised to examine the possibility of recommending that charges for private fire protection be assessed on the basis of area rather than size of connection to the distribution system. The committee should accept an assignment concerning charges for private fire protection. To this end it has been suggested that a survey be made to determine opinions and actual practices now in use throughout the country, and policies effected by utility commissions in the several states. The big problem for this committee involves an attempt to reconcile the philosophies of AWWA and National Fire Protection Association with reference to charges for public and private fire protection.

Because of the death of Dale Maffitt, Lauren Grayson has been added to the committee.

4150—Taxation and Revenue Allocation. Although this Committtee is not yet active, AWWA has had occasion to present to governmental agencies the water works viewpoint on the important subject of payment of charges due to facility relocation proposed by highway authorities. This problem remains constantly before water works managers, while an accelerated program of superhighways and turnpikes develops and continues to expand, encouraged by current federal highway program legislation and its recommended implementation.

Evidence is present in some areas that aid has been given by direct monetary means, by inclusion in the contract of a portion of the changes to be made or by furnishing both labor and material as part of the highway construction contract. Although evidence favors state control, each water works must maintain constant vigilance over local, state, and national developments.

4210M—Public Relations. Routine assistance has remained available to the AWWA staff in the preparation of *Willing Water.* For various unexplained or unsatisfactory reasons, the US Post Office Department did not grant the Association a 75th Anniversary Commemorative issue. The committee is considering the development

of an AWWA "Service Citation" to be presented to past presidents and past directors in commemoration of their terms of office.

The committee appreciates the work of Eric Johnson and the AWWA staff.

4230M—Compensation of Water Works Personnel. Since AWWA headquarters evaluated the *Survey of Employment Conditions* in 1954, the work of this committee has been negligible. It is now being activated under the leadership of Garvin Dyer who succeeded to the chairmanship upon the death of Leon Smith. As a start, it was suggested that the committee study the activities and methods of such organizations as Public Administration Service, whose services are being used extensively throughout the country, to fix responsibilities and salary rates in public service. The activated committee consists of the following: Garvin Dyer, chairman, W. R. Gelston, H. J. Graeser, John Luthin, and Robert A. Thompson.

Task Group 2210M (formed to study job classifications) is working under the jurisdiction of the Water Works Management Division.

4240M—Pension and Retirement Plans. Pressure to place state pension systems under the Federal Social Security Act continues. Changing national attitudes towards all types of pension systems will affect the water works field and will bear constant attention by this group.

Since the death of Dale Maffitt, the committee has been reconstituted as follows: John G. Copley, chairman, L. E. Goit, M. P. Hatcher, A. P. Kuranz, Leo Louis Jr. and D. P. Morse.

4250M—Safety Practices. The main activity of the four task groups of this committee was the preparation of a safety manual, *Safety Practice for Water Utilities,* which was printed serially in the JOURNAL (July–December 1955). It has been subsequently printed under its own cover and is now available from the AWWA office at a nominal cost.

The manual is applicable to small, as well as large water utilities. Safety in water works is creating very great member interest and more active participation than any other phase of water works personnel management. The committee shows excellent approach and is to be complimented highly upon its high-level activity. The need for safety committees at the section level must be stressed at every opportunity.

In the past 2 years the committee has developed an award plan for safety in water utility activities. The final plan, as approved in July 1956, was devised to maintain interest in safety programs and to stimulate a competitive spirit for safety among the utilities of each section. Because safety is a personal matter which needs an occasional pat on the back to keep its objectives foremost in our thinking, the award plan was designed to help encourage that awareness of safety which is so necessary to any successful program. In August 1956, the award plan was submitted to the Committee on Water Works Administration for consideration. By letter ballot the plan was approved by a vote of thirteen affirmative votes (one member not voting and two members failing to return their ballots). The nonvoting member stated that he thought that there were too many awards available at the section level.

The award plan is presently up for Board consideration, and, if it is approved, the Safety Practices Committee of each section will be alerted to put the plan into action. In 2 years the

plan should be in full swing. It is also anticipated that 1958 will see the first awards presented at the AWWA level. [The Board has approved the award plan (see p. 339).]

Upon the death of Dale Maffitt, Earl Stephens was appointed to the Subcommittee on Distribution—4253M.

4260M—Education. The committee, in May 1956 (at the St. Louis Conference), decided to schedule production of the six in-service training manuals by May 1957. This schedule was overly ambitious, and present estimates are that two manuals each year for the next three years can be produced. A faster schedule may eventuate, although no promise of it should be made at this time.

The writing of the manuals, as was expected, developed some difficulties. First, the idea of employing a single writer for each manual was found to be impractical. Generally, people could not be found to do the writing at the price AWWA was willing to pay. Thus, only one of the six manuals is being developed on that basis, and the number of writers has increased from two to five. The committee found that few feel qualified to write an entire manual. The manuals are as follows:

Name of Manual	Committee Member Responsible	Number of Writers
Basic Water Works Operation	I. N. Ronhovde	9
Advanced General Water Works Operation	A. P. Black	12
Ground Water Production and Treatment	E. R. Stapley	9
Surface Water Production and Treatment (completed)	E. S. Hopkins	22
Water Distribution	Fred Merryfield	5
Water Works Management	R. J. Faust	20

All manuals should be completed some time in 1957. Since each manual will contain either 128 or 160 printed pages, the size of the job becomes evident. The combined manuals will probably total 800 pages. No less than 77 members are actively participating in this endeavor. Although the committee cannot report complete adherence to its original schedule, it does report splendid progress on a rather large job. This committee is commended upon its excellent approach and outstanding enthusiasm.

4340M—Water Main Extension Policy. This committee has been continuously active. With the population trend producing suburban development, public service commission policies on main extensions will bear close watching, as will the effect of the trend to urban redevelopment.

M. P. Hatcher and L. S. Finch met in Detroit in October and developed a study program for the balance of 1956 and 1957. Since that time, some work has been done toward implementing this program. The major study items in the current program are as follows:

1. To review and analyze the report of the Engineering Committee of the National Association of Railroad and Utilities Commissioners (NARUC) on main extension policies and rules. (This review was decided upon following the meeting of the Water Works Administration Committee at St. Louis).

2. To reexamine the viewpoints of committee members on recommended policies which have proved to be controversial. This includes such items as the following:

a. Should return from main extensions be sufficient to defray the cost of mains only or of mains plus backup facilities? (The answer may appear obvious to many, but the Indiana Commission recently handed down a decision that backup facilities should not be included in determining costs).

b. Should the cost of laying mains through street intersections be included in the cost to be borne by applicants for main extensions or should they be paid entirely by the utility? (Although this previously was unanimously approved as an expense to be borne by the applicants for an extension, it was found that the current viewpoint of the committee members appears to be divided. A review of this is needed so that the committee viewpoint can be brought up to date).

c. Should the extent of free extensions be stated in feet or in dollars of construction cost? (Commissions are continuing to express free extensions in an arbitrary number of feet and to contend that this is the proper manner. Some water works men also share this viewpoint).

3. To seek an answer to problems not previously studied. Items such as the following are characteristic:

a. How to make "free riders" on main extensions pay their way

b. How to protect utility investment against "free riding" by customers on an extension to the original extension.

c. Should original depositors receive refunds because of customers on an extension of the extension which they helped finance? (This was not a controversial issue at the time the last progress report was made by the committee, but, since then, certain commissions—notably California—have decreed that new customers on extensions to extensions should be the source of a refund to original depositors on the original extension).

The committee will have developed information and opinions on these and other questions by the time of the 1957 Annual Conference at Atlantic City. The entire subject is of direct, pertinent, member concern.

4420M—Water Rates. The committee is presently at standby basis although review and revision of water rates under changing economic conditions are necessary parts of the proper administration of a healthy water utility. The widespread use of air conditioning poses a problem in rates. The control of the funds provided by rates is also a matter for constant surveillance if the water utility is to receive and use its own funds for successful operation and expansion.

4430M—Joint Administration of Water and Sewer Facilities. With the general acceptance of the sewerage service charge and its almost universal collection by the water utility office, the trend toward joint administration is expanding with attendant problems.

The membership of the committee was stabilized in June 1956, by which time all members had indicated their willingness to serve on the committee. Since that time a questionnaire has been prepared which was submitted to all members of the committee for their comments and approval. The questionnaire was sent to AWWA headquarters for preparation, from where it was sent out on Dec. 6, 1956, to water departments in all cities of 10,000 population and over—approximately 1,000. No further action will be taken by the committee until receipt of the results.

4440M—Water Use. The two groups, 4441M (Industrial) and 4442M (Residential and Commercial), are now combined under the chairmanship of H. E. Hudson and continued their studies of the effects of geography and the kinds of water needed to fill industrial requirements and will outline the various schemes for industrial water conservation. The combined group is studying the various trends and demands of domestic uses, with

particular stress upon the causes of per capita increase and seasonal and hourly variations. The many divergent uses of water will, in time, produce areas of conflict, requiring careful analysis of the possible priority of use of some supplies. Regulations against waste are forthcoming. Studies in the office of the chairman on population trends, combined with water use trends, have been in progress. These data indicate a number of factors not hitherto taken into account in water use forecasts that may cause upward revision of estimates for the period 1960–70.

4450D—Revenue-Producing Water. This committee has been expanded and an attempt is being made to arrive at a more descriptive name. The committee works in the field of interest of the Water Distribution Division, which is giving valuable assistance and impetus. The manual as proposed will be a comprehensive assembly of papers and related matters with a proper digest of the material to eliminate duplication and to separate extraneous matter. The work will be evaluated through committee action to bring any particular subject into proper focus. It will also contain a comprehensive bibliography of the subject. This will prove of particular value since no list is now available. By this means, manuals of specific interest could be prepared and purchased at low cost. A draft has been prepared for review of the committee membership. The term "metered ratio" is used throughout. A report is planned before the Distribution Division at the Atlantic City conference. E. D. Case has accepted a place on the committee.

Research and Development Groups

2210M—Job Classifications. This is a task group in the province of the Management Division and is just getting under way. It will be helpful to Committee 4230M (Compensation of Water Works Personnel). Considerable progress in outlining the work of the committee is being made. A committee conference is scheduled during the Atlantic City meeting.

2220M—Review and Redevelopment of Rating Scale for Water Works. The chairman of the group and its members have spoken before sections of the Association and before other interested water works groups on the value of the group's work. It is believed that several years will be required before it can be said that the work is approaching completion. So far, it has been determined that the group will concern itself with the following general phases: [1] financing, rate structure, and metering; [2] general and customer accounting, collecting and billing, and recording of data; [3] managerial responsibility and authority, and personnel training; [4] source of supply, and transmission and provision of pressure; [5] purification and treatment; and [6] distribution. Cooperating task groups are being set up for all of the foregoing phases. An attempt is being made to select members in the same geographical area. The groups have been given suggestions for pursuit of their studies, and the chairman has asked for time at the Atlantic City conference for the task group to get together. He says: "The work can be done, and we can produce a system which will be both workable and advantageous."

2230M—Committee to Cooperate With NARUC Committee on Revision of System of Accounts for Water Utilities. This committee has worked earnestly and hard for more than 3 years in an attempt to bring the system of

accounts promulgated by NARUC into realistic relationship with the construction and operating practices of water works utilities. Although these rules are mandatory only upon the operators of privately owned utilities, the classification of accounts is extensively used in publicly owned systems. Encouraging avenues of agreement present themselves from time to time, so that in the end, many favorable changes may result. The committee's approach to the handling of this problem has been excellent.

2240M—Committee to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Service. The committee has been attempting to cooperate with the NARUC Engineering Committee and several conferences have been held. The AWWA Committee has not, however, gone along with ideas which it cannot approve. It is believed that the work of the committee is approaching completion. It should remain alert, however, to study detailed proposals in the various states. J. H. Murdoch and the committee are performing an arduous task well.

Recommendations

The attention of the board is again directed to the necessary enlarging of the activities of the Committee on Water Works Administration along several lines, as hereinbefore noted. There are numerous projects of the committee which cannot be handled efficiently on a member-committee basis. They involve a large amount of research and could best be handled in New York as staff projects. The Association's budget might be supplemented by outside funds, especially when a project involves items in which manufacturers or industries are vitally concerned. The subcommittee activities which might be considered as projects requiring staff aid are:

4110M—Constitution and Statutory Aspects of Municipal Water Works Organization

4150M—Taxation and Revenue Allocation

4230M—Compensation of Water Works Employees (see 4230M and 2210M above)

2240M—Rules & Regulations (see 2240M above). Like 4110M this is a vital subject, but not suitable for a nationwide formula. Both require research at the state or restricted level.

It is the aim of the Committee on Water Works Administration to proceed deliberately, acting upon and anticipating obvious member demands and expanding interests; to establish a long-term policy of continuing activities; to maintain close cooperation with the Committee on Water Works Practice; and to encourage member participation in task groups of the various divisions. Appreciation is hereby extended to the AWWA personnel and to all committee chairmen and members for the many services rendered. The ever valued counsel, consideration, and advice of the members of the Board of Directors are gratefully acknowledged.

AWWA Safety Award Plan

ON Jan. 28, 1957, the Board of Directors of AWWA at its annual winter meeting considered and unanimously approved a Safety Award Plan for water utilities. This action of the Board achieved an objective of the Committee on Safety Practices that had been under consideration for almost 2 years. As Wendell R. LaDue has been, in effect, the AWWA member responsible for the initiation of the award plan as a whole, the Board agreed that the three general AWWA awards should be titled the "Wendell R. LaDue Awards."

The award plan was developed with the purpose of stimulating water utilities to: [1] start safety programs where none existed; and [2] keep already organized and operating safety programs at a high degree of efficiency. It will be recalled that a manual on "Safety Practice for Water Utilities" was written by the Safety Practices Committee and published in the July–December 1955 JOURNAL. In 1956 the manual was published under its own cover and is available at nominal cost from AWWA. The award plan was thus the next logical step toward a well rounded safety program for the industry.

The plan as approved does not permit direct competition between towns. That type of approach was impractical because of the large number of variables that had to be reconciled. Although competition is desirable, the committee learned that it had to develop from within rather than from outside of the utility. In other words, the award system was set up so that a utility could compete with itself. That is much the same as a golfer competing with par rather than with other golfers. Thus, the incentive which competition affords was retained.

The Safety Award Plan is divided into two parts. One relates to the Sections and the second to the parent Association. Awards at the Section level will be given on an annual basis to all utilities that earn them. AWWA awards will also be given annually, but the number will be limited to three.

Award Plan for Sections

The Safety Award Plan for Sections is based on the establishment of three awards: [1] the Award of Honor, [2] the Award of Merit, and [3] the Award of Progress, the first being highest.

The conditions of eligibility for the awards are simple. For example, utilities will annually be eligible for the *Award of Progress* by demonstrating a prescribed percentage reduction in the injury frequency rate when compared with the previous year. Thus, to be eligible for an award, a utility must keep a safety record for at least a year prior to the year for which the award is won. The reductions required to be eligible for an Award of Progress are: for utilities with less than 10 employees, 50 per cent or more; 10–100 employees, 30 per cent or more; over 100 employees, 20 per cent or more. The variations in percentage reduction were necessitated by the wide range in the number of employees per utility, which varied from

one to more than 3,500, and resulted in large variations in exposure to risks.

The *Award of Merit* is an interim award for utilities employing not more than 50 people. It is awarded to those utilities that have experienced no lost-time injuries during the year. The number of consecutive Awards of Merit required to earn an Award of Honor are as follows:

No. of Employees	No. of Awards of Merit
1–9	5
10–19	4
20–29	3
30–39	2
40–49	1
50 or more	0

The top award, the *Award of Honor*, is earned annually by those utilities that attain a frequency rate of 10 or less and employ 50 or more people. It is also earned by the smaller utilities by fulfilling the requirements as set forth under the Award of Merit. The Award of Merit was interposed between the Award of Progress and the Award of Honor to produce some semblance of equality in earning the top award. It was recognized that, for the smaller utilities, the attainment of an injury frequency rate of 10 or less would represent no outstanding accomplishment.

The arbitrary injury frequency rate of 10 was chosen as the criterion for an outstanding safety accomplishment because it represents a reduction of 55 per cent from current average injury frequency rates in the industry. The committee believed that, for the present, the attainment of such a reduction was worthy of recognition. Later, if progress in safety proceeds as expected, the award criteria may be adjusted to retain the value of the award.

The three Section awards will consist of $8\frac{1}{2} \times 11$-in. certificates properly designated and carrying the names of the Section chairman, Section secretary, and chairman of the Section safety committee.

Award Plan for AWWA

Safety awards are also available at the parent Association level—one per year for each class size of utility. The three class sizes are: Class Size 1—utilities employing less than 10 people; Class Size 2—10–100 people; Class Size 3—more than 100 people. These Wendell R. LaDue Awards will be granted only for outstanding accomplishment in safety during a calendar year. The awardees will be chosen by the AWWA Committee on Safety Practices from information sent to it by the various sections. Only Section awardees will be eligible for the AWWA awards, and only one candidate for an award in each class size may be submitted by a Section. Thus, at present, a maximum of only 30 applications in each class size will need to be reviewed by the committee to choose awardees. The AWWA awards will be plaques suitably inscribed.

Award Plan in Action

It is recognized that the success of this award plan depends almost completely on the activity of the safety committees of the Sections. With energetic committees, the plan can achieve great results and make the water industry a safe place in which to work. With indifferent committee activity, the plan may never get off the ground. Thus, it is important that the membership of the safety committees be selected with care and that the Sections back up its committee wholeheartedly. With that type of interest prevailing, the award plan will surely succeed and the water industry greatly benefit.

Report of the Committee on Water Works Practice

For the Year Ending December 31, 1956

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1956, submitted to the AWWA Board of Directors on Jan. 28, 1957, by Louis R. Howson, Chairman.

THE working committees operating under the jurisdiction of the correlating Committee on Water Works Practice have continued, during the year 1956, their diligent service in the interest of the water supply industry and its advancement.

Watersheds. During 1956 a letter survey was made by Secretary Jordan on state sanitary engineer requirements regarding ownership of land adjacent to water supply impounding reservoirs. The survey indicated a substantial lack of uniformity in the various states. Climate and the land use practices in the various states vary so widely that it would not appear practical to suggest a uniform method of control of reservoir lands. The material is being consolidated by Francis S. Friel into a paper which will be presented at the Atlantic City conference.

Impounding reservoirs. Likewise, there is a substantial difference of opinion among water utility operators concerning the access of the public to the watershed areas and to the water in impounding reservoirs. In some of the eastern and middle western states, the recreational use of reservoir waters and adjacent land areas is permitted when the water is completely treated (including filtration) thereafter. However, on the west coast and the east coast, where impounding is not generally followed by complete treatment, the attitude of water works executives is to prevent access to the land areas and waters of such reservoirs. Further discussion of this subject is scheduled as part of the technical sessions at Atlantic City.

Deep wells. The National Water Well Association has requested AWWA to consider certain modifications of its existing Specifications for Deep Wells (A100). The changes suggested do not affect ability to get good competitive bids. Information is being collected to ascertain just exactly what the existing commercial practices of the steel industry are in the manufacture of casing pipe for wells. The current AWWA specification lists internal and external diameter requirements for well pipe that are not currently in accord with the Wisconsin Well Code —more or less the model of state codes in this regard. Such items as standard weight casings, while suitable for mild Wisconsin waters, may not be for corrosive Gulf Coast waters or where a well is close to possible contamination. Even the Wisconsin Code appears not to coincide with the commercial practices of the steel industry.

Water Purification

Corrosion prevention. A sponsored research project on the effect of water treatment methods upon hydraulic conditions within water distribution lines continues as a National Institutes of

Health funded project at the University of Illinois under the direction of T. E. Larson. The Goodell Prize Committee has recommended the conferring of that award for 1957 upon Mr. Larson for his latest report upon the progress made in his studies.

Water treatment. The specifications for the following chemicals have been considered:

Fluorides. Certain deficiencies in the current specifications for sodium fluoride and sodium silicofluoride have been noted. A special task group has been appointed to prepare revisions. Recommendations from this task group should be available by mid-1957.

Lime. Suggestions made by the National Lime Association for modification of the existing specifications and methods of test for lime used in water treatment have been considered and a consensus reached with the referee. The recommendation of the Lime Association that the slaking test be omitted is not acceptable to the referee. The suggestion that dolomitic lime be included is likewise not acceptable. Certain clarification of phraseology has been agreed upon and the material will be circulated within the executive group of the Purification Division for clearance prior to the Atlantic City conference.

Liquid chlorine. A special task group on specifications for liquid chlorine prepared a text which was acceptable to the committee, but not acceptable to the producers. It is going to be necessary to carry through a research project on methods for testing for impurities in chlorine before a specification can be completed. Although existence of certain impurities is known to the chlorine-producing industry, generally accepted methods of test for these impurities are not yet available.

Copper sulfate. Specifications for copper sulfate have been prepared, but the officers of the Water Purification Division do not agree with the referee on certain details. It will be necessary to overrule the referee and put forward the text which is acceptable to the division officers.

Joint Committee on Chlorine Supply. The Joint Committee on Chlorine Supply as such has been inactive during the past year. Near the end of 1956, one of the important cities of the country faced the problem of lack of bids for a 1957 supply of chlorine from any one of the producers. The matter was called to the attention of the AWWA staff and by the staff to the Water and Sewerage Industry and Utilities Division of the Department of Commerce. Richard Ford, director of that division, presented the situation to the head of the Chemicals Division of the Department of Commerce and as a result of their joint activities, the city in question was able to obtain a definitely contracted supply of chlorine for 1957.

Joint Committee on Oil Line River Crossings. This committee has made no progress during the year; partly because of the fact that AWWA representatives have been too greatly involved in their own activities and partly because the oil industry representatives lack aggressive interest in the problem. Oil line river crossings are important and the project should be speeded up. Even more important is the responsibility of the oil industry for cleaning up its wastes—a case where some refineries have made real progress. It is suggested that a committee be set up to gather all the available data on: [1] what the oil industry is doing to reduce the load on streams; [2] the magnitude of oil refinery pollution load; [3] pollution tolerance from oil wastes that

can be handled in conventional water treatment plants; and [4] unusually difficult and costly procedures forced on water works to cope with oil wastes. [The Board recommended to the Water Purification Division the advisability of setting up a task group to study pollution, particularly that by oil refinery wastes.]

Pipe design allowances for water hammer. A very competent task group has been set up under Chairman Logan Kerr. The group includes representatives of the producers of cast-iron pipe, steel pipe, asbestos-cement pipe, and reinforced concrete pipe. It also includes three consulting engineers and a consumer representative. The task group is making extraordinarily fine progress. A special study is being made of the consumer-installed devices which produce serious surges in water distribution pressure. A further study is being made of the record of breaks in pipelines which appear to derive from water hammer. There is every evidence that the results of this task group will be highly beneficial to the water works industry. A preliminary report is scheduled for presentation at the Atlantic City conference.

Joint Committee on Spillway Design. This joint activity of AWWA and ASCE was initiated after a special study committee of the two organizations had recommended that formal committee activity be carried on. Chairman Thomas H. Wiggin has not found it possible to develop the cooperative support from ASCE which this project requires. [Relevant to this, L. R. Howson, chairman of the Committee on Water Works Practice, made the following motion at the 1957 annual meeting of the Board: "The Executive Committee, acting on the advice of the chairman of the joint committee, with the cooperation of the chairman of the Water Works Practice Committee, is directed to recommend whether the AWWA should continue in or withdraw from this joint venture. If the withdrawal is recommended, the Executive Committee may also request the present joint committee personnel to proceed with the study under AWWA sponsorship, limiting the study to dams and spillways appurtenant to reservoirs of water works size." [The Board approved.]

Water Distribution

Joint Committee on Backflow Prevention. This committee has evidently made little progress during the year 1956. What was intended to be a final report of the joint committee was circulated early in the year. It brought forth suggestions for a number of modifications of the text which have not yet been made effective. This project bears upon existing administrative practices of state sanitary engineers and the content of a great number of plumbing codes. Completion of the work cannot be expected promptly.

Cast-iron pipe. A revision of the Recommended Practice Manual for the Computation of Strength and Thickness of Cast-Iron Pipe (ASA A21.1; AWWA C101) has just been cleared by the committee chairman and is now being mailed to the four sponsor organizations. The text is a revision of the document approved in 1939. It is much more complete than was the original text. Publication as an official document is expected by mid-1957.

Reinforced concrete pipe. Specifications for Reinforced Concrete Water Pipe, Steel Cylinder Pipe, Not Prestressed (C300), and for Reinforced Concrete Pipe, Noncylinder Type, Not Prestressed (C302), are being revised

to bring their phraseology into accord with the latest revision of Specifications for Reinforced Concrete Pipe, Steel Cylinder Type, Prestressed (C301). The preliminary report on the Manual for Installation of Reinforced Concrete Pipe is promised for presentation at one of the technical sessions of the Atlantic City conference.

Asbestos-cement pipe. The Specifications for Asbestos-Cement Pipe (C400), which have been held in tentative status since 1953, await the results of certain findings which are expected from the Task Group on Water Hammer Allowances before any definite steps are taken toward revision of the existing document. If, in the meantime, any member of the Board of Directors wishes to suggest any modification or revision of the Specifications for Asbestos-Cement Pipe, those suggestions would be most carefully considered.

Steel pipe. A major revision of the Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe (C203, C204) is complete and ready for final approval by the working committee. A revision of the Specifications for Cement-Mortar Protective Coating for Steel Pipe (C205), is in process of production.

A new specification for spiral lap-steam welded pipe is in process of development.

A manual on the design and installation of steel water pipe, which has been under preparation for several years under the direction of Russell Barnard, is in its final draft and is ready for circulation among the members of the committee. It may be ready for Board approval by May 1, 1957.

Minor revisions to Specifications for Welded Steel Pipe (C201, C202), have been completed.

Hydrants. There has been no activity with relation to revision of the hydrant specifications during 1956.

Sluice gates. There has been no activity during 1956.

Valves. A new committee has been appointed and revision of the Specifications for Gate Valves for Ordinary Water Works Service (C500) has been initiated during the year 1956 under the chairmanship of David Auld. The committee has replied to an initial communication from the chairman and is reasonably in accord concerning the major changes that should be made.

Special consideration is being given to the composition and the dimensions of valve stems. The committee can be expected to reach a consensus during 1957.

Butterfly valves. The Specifications for Butterfly Valves (C504, C505) are being actively studied by the committee under the chairmanship of F. G. Gordon. A number of suggestions have been received from manufacturers, which this committee is taking fully into account. Work already done by this committee is of the highest value to the water works industry.

Meters. Chairman Carns of the Meter Committee has in preparation a manual which will be considered by his committee at the time of the Atlantic City conference and probably submitted for approval shortly thereafter.

The Recommended Procedure for Testing Water Meters (which was published in *Willing Water* No. 40 for June 1956) has brought forth only two comments and will be presented to the Board for approval during this meeting. [The Board approved.]

Service line materials. Under staff auspices, an informal study is being made of the requirements for copper tubing used for water service lines. It is known that several of the larger water utilities are using Type L copper

tubing, instead of Type M, because of the thinner wall and less weight per foot and, therefore, less cost. The studies of certain specimens of installed copper service lines are being made to see what the nature of the depreciation may have been, and whether or not the adoption of a thinner walled copper tubing is justified.

Plastics. Considerable pressure has been exerted to bring about an AWWA specification for service line material made of the so-called "plastics." Recommendations are made that a committee be established to evaluate the presently available plastic pipe, or tubing and fittings for the same, looking toward the development of an AWWA standard for plastic materials for service lines. [The Board approved the appointment of this committee.]

Joint Committee on Steel Standpipes and Elevated Tanks. No activity is current in this field. The extraordinarily competent chairman of this committee, H. O. Hill of Bethlehem Steel Company, has retired from active service with his company and the committee is presently being reorganized. Mr. Hill is entitled to the highest tribute that can be given for the work that he has done.

Manual of Water Quality and Treatment. Revision of three chapters of this existing book have been made and published (Aug. 1955, Sep. 1955, Jul. 1956). They are the chapters on aeration, on mixing, flocculation, and settling and the shapter on filtration. Certain criticisms of a portion of the last chapter mentioned have been received and a revision of that portion of the text has been made.

ASCE-AWWA Manual, Filtration of Water. This manual of design is in process of being revised by a committee headed by Ray Derby of the Los Angeles Water Department. Only a small portion of the revised text is in the hands of the chairman.

Standard Methods for the Examination of Water, Sewage and Industrial Wastes. The Joint Editorial Committee for the 11th edition of *Standard Methods* was organized with Wellington Gilcreas of APHA as the chairman, Michael Taras representing AWWA and Gail Edwards representing the Federation of Sewage and Industrial Wastes Associations. Mr. Taras, representing AWWA, is doing a very forthright and competent job. The Association is to be congratulated in having his services available. The 11th edition of *Standard Methods* is scheduled for 1960.

Joint Committee on Uniformity of Methods of Water Examination. This committee was organized during the year with Mr. Gilcreas as chairman. This is an interassociation activity intended to avoid conflicts in detail and in basic methods for water examination.

Water Resources

Task Group on Weather Control. This task group has been reorganized under the chairmanship of Burton S. Grant of the Los Angeles Water and Power Department. A preliminary report may be expected at the time of the Atlantic City conference.

Task Group on Production of Usable Water From Salt Water. The chairman of this task group, W. F. Langelier, has retired from active service to the University of California and the group is presently inactive. At the Atlantic City conference a report upon the study sponsored by the Department of Interior will be presented by David Jenkins, head of the operation.

Task Group on Watershed Protection and Erosion Control. This group is presently inactive. Incidental to this matter, it should be noted that the As-

sociation is participating in the sponsored research project at the Southwest Research Institute. The study has to do with the reduction of evaporation losses in stored water by use of certain protective surface films. A review of the situation as it stands today will be presented at the Atlantic City conference by a representative of the Bureau of Reclamation.

Task Group on Artificial Ground Water Recharge. The chairman of the group will present a progress report at the time of the Atlantic City meeting.

Task Group on Underground Waste Disposal and Control. The chairman of this group proposes to have available a report in final form by April 1957.

Other Activities

Nine task groups which are in active study of the material assigned to them and from which progress reports are scheduled for presentation at the Atlantic City meeting, are as follows:

Advisory Committee on Chromium and Cadmium Solubility and Toxicity

Task Group on Fluoridation Materials and Methods

Task Group on Instrumentation and Methods of Testing Radioactive Contamination in Water

Task Group on Molecular Filter Membranes

Task Group on Survey of State Regulations on Water Treatment Plant Design

Task Groups on Synthetic Detergents

Task Group on Biological Infestation of Purified Water

Task Group on Manganese Deposition on Pipelines

Task Group on Cold-Water Corrosion of Copper

The Association participates in the activities of several committees under the procedure of the American Standards Association. The following have been formally completed and approved during the year 1956:

Scheme for the Identification of Piping Systems (A13)

Marking Compressed Gas Cylinders (Z48)

Storage and Handling of Anhydrous Ammonia and Ammonia Solutions (K61). (Now ready for letter-ballot among the members of the committee.)

The following projects have recorded no progress during 1956:

Pipe Flanges and Fittings (B16)

Fire-Hose Coupling Screw Thread (B26)

Code for Pressure Piping (B31)

Standardization of Screw Threads for Hose Couplings (Other Than for Fire Hose Couplings) (B33)

Standardization of Abbreviations (Y1)

Letter Symbols (Y10)

Graphical Symbols and Designations (Y32)

Standards for Drinking Fountains (Z4.2)

Specifications for Sieves for Testing Purposes (Z23)

Fluid Permeation (Z59)

Deep well turbine pumps. The Specifications for Deep Well Vertical Turbine Pumps (A101) are prepared by a joint committee (for which AWWA is sponsor). The committee prepared a very competent document which was approved under ASA procedure in 1955. The committee is presently considering suggestions which have been made for a revision of the existing document. The committee has in preparation a field manual for testing deep well pumps. It has also been authorized to develop a standard for submerged centrifugal pumps, but this project is temporarily laid aside until more consistency is noted among the

units now presently available for sale to the industry.

Products certification. Very careful consideration is being given to the development of a certification or approval procedure which will make certain, to purchasers of products and persons who refer to AWWA specifications, that the terms and conditions of the specifications are carefully followed by the manufacturer.

Personnel Changes

Changes in committee personnel are required to be reported to the Board in accordance with the Association's standardization procedure (Sec. 3.3.3) governing technical committees, which says: "Such changes in committee personnel shall be reported to the Board at one of its stated meetings."

Committee on Water Works Practice. H. O. Hill resigned (because of his retirement from Bethlehem Steel Company), and was replaced by Vance C. Lischer of the consulting firm of Horner & Shifrin, St. Louis.

Special Task Group to Study Allowances for Water Hammer. Max K. Socha resigned and suggested as his replacement Richard E. Hemborg, Engineer of Water Distribution, Los Angeles Department of Water & Power. The substitution was made.

Steel Pipe Committee. There were two substitutions made because of retirement. H. R. Redington of National Tube Division, U. S. Steel Co. was replaced by B. F. Hughes, Product Manager, Fabricated Plate Products, Alco Products, Inc., Dunkirk, N.Y. H. O. Hill of Bethlehem Steel was replaced by J. H. Easter of the same company. Mr. Easter also replaces Mr. Hill on the Steel Pipe Subcommittee on Standards for Steel Pipe Flanges.

Joint AWWA-AWS Committee on Field Welding of Steel Water Pipe Joints. J. H. Easter also replaces Mr. Hill on this committee. L. G. Lenhardt has been retired from the Detroit Water Department and resigned from the committee. H. A. Price has been appointed chairman of this committee to replace W. W. Hurlbut who is inactive.

Joint Committee on Steel Standpipes and Elevated Tanks. H. O. Hill has been replaced on this committee by S. A. Wilson of the same company. It is suggested that Joseph P. Schwada who is retired and inactive be replaced by Leslie Paul of East Bay Municipal Utilities.

Valve Committee. This committee was reactivated during the year under the chairmanship of David Auld. The other members appointed to the committee are:

Carl F. Buettner, Distr. Section, Water Div., St. Louis
Kenneth J. Carl, Engr., National Board of Fire Underwriters, New York City
Richard H. Ellis, Engr., Factory Mutual Engineering Div., Boston
Hubert F. O'Brien, Pres., A. P. Smith Mfg. Co.
A. C. Michael, Supt. of Eng., Dept. of Water Supply, Detroit
Leslie Paul, Supervisor Mech. & Elec. Engr., East Bay Municipal Utilities District
Carl H. Simon, Vice-Pres. & Chief Engr., Darling Valve & Mfg. Co.
Loring E. Tabor, Spec. Engr., Los Angeles Dept. Water & Power.

Task Group on Biological Infestation of Purified Water. Charles E. Renn, Professor of Sanitary Engineering, Johns Hopkins University, was ap-

pointed chairman to fill the vacancy created by the death of Blair Burnson.

Task Group on Manganese Deposition in Pipe Lines. A. E. Griffin of Wallace & Tiernan agreed to relieve Roy Dodson of the chairmanship of this task group. Mr. Dodson will remain on the committee and will probably be designated vice-chairman.

Task Group on Filterability Index. This task group has been organized under the chairmanship of Douglas Feben. The other members appointed are:

Clayton M. Bach, Supt. of Water Treatment, Minneapolis
J. A. Borchardt, Assoc. Prof. Civil Eng., Univ. of Michigan
A. E. Bowers, Research Chemist, Metropolitan Water District of Southern California
John F. Dye, Plant Engr., Water Conditioning, Lansing, Mich.
Oscar Gullans, Chief Water Chem. Engr., Chicago
Harry N. Lowe, Jr., Chief Water Purif., Fort Belvoir, Va.
D. H. Matheson, Hamilton, Ont., Canada
J. R. Popalisky, Supt. of Purif., Kansas City, Mo.
Jos. M. Sanchis, San. Engr., Los Angeles Dept. Water & Power
Kenneth Edgar Shull, Chief Chemist & Supt. of Purif., Philadelphia Suburban Water Co., Pa.
P. L. Boucher, Chief Civ. Engr., Glenfield & Kennedy, London, England (appointed as a consultant).

Task Group on Diatomite Filtration. This task group has been organized under the chairmanship of E. Robert Baumann, Iowa State College of Agriculture & Mechanical Arts. The other members of the committee are:

Henry Armbrust, Proportioneers, Inc., Providence, R.I.
George R. Bell, Research Chemist, Celite Applications Section, Johns-Manville Research Center
Harry N. Lowe, Jr., Chief, Water Purif. Div., Fort Belvoir, Va.
George W. Moore, Chief Water Engr., New York State Dept. Health
Joseph M. Sanchis, San. Engr., Los Angeles Dept. Water & Power.

Advisory Task Group for Chemical Specifications. The members of this new committee are:

Oscar Gullans, chairman, Chief Water Chem. Engr., Chicago
W. L. Harris, Water Plant Supervisor, Grand Rapids, Mich.
M. Starr Nichols, Chemist, State Lab. of Hygiene, Madison, Wis.

Report on Publications

For the Year Ending December 31, 1956

A report on the publishing activities of the Association for the year ending Dec. 31, 1956, submitted to the AWWA Board of Directors on Jan. 28, 1957, by Eric F. Johnson, Asst. Secretary—Publications.

DURING 1956 a reinforced staff was successful in increasing the size of the text section of the JOURNAL by more than 350 pages. Meanwhile, advertising continued to set new records in both volume and income, to offset a major portion of the additional cost of the larger JOURNAL. The new safety manual was issued in March, so that by the end of the year a thousand copies had been sold. And late in December, the new cumulative index, covering the JOURNAL volumes from 1940 through 1955, finally appeared—quietly, however, to postpone the sales burden on the bookeeping department, at that time submerged in dues receipts.

Published in 1956, too, were an anniversary booklet and a special membership promotion folder that were sent to all members as part of the Association's Diamond Jubilee celebration. And celebrating the appearance of its 1,000,000th copy was AWWA's bestselling cartoon booklet, *The Story of Water Supply*.

1. The Journal

A detailed picture of JOURNAL contents, costs, and income for the years 1951–56 is presented in Table 1.

a. Contents. Although the increase in JOURNAL size authorized by the Board at its 1956 meeting did not get under way until the May issue—the first on which the additional editor was employed—the text section fell only 44 pages short of the total that had been projected as a goal for a full year of larger JOURNALS. This increase of 356 text pages made room for 34 more articles than had been used in any of the past 6 years and, so, served to relieve much of the backlog of accepted manuscripts that had piled up during 1955. Thus, too, for the first time in many years, all the annual conference papers available for publication were published in the year of their presentation. This catching up, of course, meant that 1½ conference programs were included in a single year's issue, to produce the unusually high total of conference material shown in Table 1.

In the advertising section, further economies in the use of space actually resulted in a decrease in the number of pages used despite an increase of 18 pages in the total of paid advertising. Again, these makeup economies meant a reduction in the space available for abstracts and for the "Percolation and Runoff" section, but with the desired balance of text and advertising sections once more restored, some expansion of abstracts and news space can be contemplated in 1957.

b. Cost and income. The significant increase in costs shown in Table 1 reflects both the 28 per cent increase in size of the JOURNAL and the 5 per cent increase in circulation, as well as in-

TABLE 1

Journal Contents, Costs, and Income, 1951–56

Item	1951	1952	1953	1954	1955	1956
Contents						
Text pages	1,076	1,218	1,378	1,366	1,262	1,618
Advertising pages	1,340	1,390	1,182	1,258	1,282	1,262
Total pages	2,416	2,608	2,560	2,624	2,544	2,880
Text articles						
Conference papers	32	28	21	24	23	54
Section papers	44	68	61	67	90	60
Contributions	20	25	24	36	19	50
Reports & official documents	22	24	33	18	13	15
Total articles	118	145	139	145	145	179
Abstract pages*	94	108	85	75	72	55
Costs†						
Production	$ 3,706	$ 5,187	$ 4,921	$ 4,598	$ 5,303	$ 8,144
Printing	37,234	42,521	47,036	46,182	47,217	55,266
Paper	10,742	13,876	14,088	15,207	15,232	19,033
Total Costs	$51,682	$61,584	$66,045	$65,987	$67,752	$82,443
Total cost index‡	105.5	125.7	134.8	134.7	138.4	168.8
Cost per copy	42.5¢	45.9¢	47.5¢	46.7¢	45.9¢	53.0¢
Cost per 1,000 pages	$ 2.07	$ 2.07	$ 2.19	$ 2.09	$ 2.13	$ 2.17
Printing rate index‡	107.9	107.9	113.3	115.5	115.5	116.1§
Paper rate index‡	111.4	118.2	118.2	120.6	123.1	130.1
Income						
Advertising	$72,639	$85,147	$85,076	$100,951	$107,209	$115,816†
Subscriptions	$ 6,797	$ 7,094	$ 7,510	$ 8,943	$ 9,172	$ 9,879
Total pages paid advertising	847	879	856	926	969	987
Advertising rate index‡	100	113.3	113.3	124.0	124.0	133.3
Cost per 1,000 circulation	$ 8.25	$ 8,73	$ 8,30	$ 8.70	$ 8.17	$ 8.34
Circulation (avg per issue)	9,094	9,740	10,238	10,687	11,385	11,993
Circulation index‡	106.8	114.4	120.2	125.5	133.7	140.8

* On basis of present format.
† At variance with audit figures because of different basis.
‡ 1950 = 100.
§ Increase of 6.7 per cent effective with December issue.

creases in both the paper and printing prices. Actually, the 6 per cent paper rate rise had a considerably greater effect than the larger boost in printing rates, for the latter did not go into effect until the December issue. The sizable rise in production costs is traceable almost entirely to the additional drafting and engraving costs for the larger issues, but also included is the first full year of expenses for author offprints—an item of approximately $930. These various factors serve to explain why cost per copy rose so sharply, while cost per 1,000 pages remained virtually unchanged.

TABLE 2

Relation of Journal Cost to Advertising Income, 1951–57

Year	Total Cost $	Advertising Income $	Dollar Spread $	Percentage Spread %
1951	51,682	72,639	20,957	40.5
1952	61,584	85,147	23,563	38.3
1953	66,045	85,076	19,031	28.8
1954	65,987	100,951	34,964	53.0
1955	67,752	107,209	39,457	58.2
1956	82,442	115,816	33,374	40.4
1957*	93,500	120,000	26,500	28.3

* Budget figures.

As indicated earlier, additional income from advertising offset more than half the additional costs of the larger JOURNAL. This was made possible despite the relatively small increase in space sales by virtue of the 7 per cent increase in advertising rates made effective in January 1956. Subscription income, meanwhile, continued its steady rise.

Overall, both costs and income exceeded budget estimates by approximately 3 per cent.

c. The future. For 1957 a slightly larger JOURNAL is planned, first, to bring the text section up to the 1,650-page level projected last year and, second, to permit expanding the advertising section, for both additional advertisements and additional abstracts and news features. Although the proposed increase in size is less than 3 per cent, the full effect of the increase in printing rates, a continuation of the advance of paper prices, and the growth in circulation are expected to combine to increase the overall costs about 12.7 per cent, making next year's budget $93,500. On the basis of present advertising contract gains and losses, a small gain in space sales for the year has been estimated. With the same rates established for the year, advertising revenue for 1957 is estimated at $120,000. This may very well be too conservative, but because advertising contracts are subject to cancellation on short notice and because much of the growth in JOURNAL advertising during the past year or two has been in sales to companies that are new to the field, it is felt that optimism must be cautious.

With the indication that the spread between direct JOURNAL expense and advertising income (*see* Table 2) will suffer another significant drop in 1957, and with circulation up more than 12 per cent in the past 2 years, it appears now that another advertising rate increase will be justified. Sometime before August 1957, when 1958 rates must be established, the facts will be presented to the Finance Committee for decision.

Incidentally, some comment on the "new look" of the 1957 JOURNAL should be made, to point out that a picture cover which overcame all the objections of the past was finally achieved by modifying the former cover

design to retain full information on contents while making room for a small picture. In the picture, it is expected to feature some aspect of the contents.

2. The Directory

Although the number of members listed in the 1956 membership list edition of the *Directory* was 11 per cent greater than in 1954, the book itself was only 6 per cent larger because of the transfer of the Directory of Committees to the reference edition last year. This last step in the splitup of the original biennial *Directory* leaves only the membership lists and advertising in the even-year edition and, thus, with further economies in type size or makeup unlikely, means that this edition will, from now on, grow in direct proportion to the growth of membership. Not only larger, the membership list edition promises to become more and more expensive as the price scale outstrips the economies of size and quantity. Even so, with the growth in size a sign of the Association's health and the increase in cost being more than offset by increased advertising revenue, the situation is hardly an unhappy one. Thus, though the expense of the 1956 edition rose to $1.00 per member, the net cost per member remained the same as in 1954—42 cents—and the net cost per copy actually went down 8 per cent (*see* Table 3).

That advertising has been the key to providing an ever larger and more useful *Directory*, while keeping the financial burden within bounds, is obvious from a comparison of the last adless *Directory* with the combination of the 1955 and 1956 editions. The 1946 *Directory*, listing 6,100 members, was 256 pages in length and cost $4,000, or 42 cents per copy. The combined 1955 and 1956 editions, listing 11,100 members, were 448 pages in length and cost $17,000, or $1.16 per copy, yet the net cost per copy was only 28 cents, a third less than the 1946 cost.

Other societies have taken another route to economy in the production of their membership lists, by providing copies only to those members who request them. By this means, some organizations have reduced their print orders as much as 75 per cent. Against this method of economizing it must be pointed out that even a reduction of 75 per cent in print order would mean no more than a 32 per cent saving in overall costs, because the basic production job is still the same. But more important than that, any reduction in the distribution of the *Directory* would reduce its value not only as a reference book, but as an advertising medium, and, thus, space sales and, necessarily, advertising rates would also be reduced. As a result, the saving from reduced print orders would be much more than offset by reduced advertising income.

TABLE 3

Comparative Data on Directory *Membership List Editions, 1952–56*

Item	1952	1954	1956
Members included	9,247	10,000	11,138
Total pages	256	256	272
Number of copies printed	12,130	12,643	15,047
Total cost	$8,527	$9,036	$11,190
Cost per 1,000 pages	$2.70	$2.59	$2.69
Cost per copy	70.3¢	71.5¢	74.4¢
Cost per member	92.2¢	90.3¢	$1.00
Total pages paid advertising	51	46	56
Advertising income	$4,763	$4,802	$6,557
Net cost per copy	31.0¢	33.5¢	30.8¢

For the reference edition of 1957, a budget of $8,000—35 per cent above the cost of the similar 1955 edition—is being proposed. And advertising income is estimated at $7,000. That will mean a net cost per copy of less than 9 cents on this odd-year edition.

3. Specifications and Reprints

In 1956, as in 1955, only two sets of new specifications were issued—those for metal-seated butterfly valves (C505) and for dimensions for steel water pipe fittings (C208)—yet overall sales of specifications increased a spectacular 36 per cent, from $11,800 to more than $16,000. Again it may be pointed out that the basic reason for this large increase is the increased acceptance and use of AWWA standards throughout the field. Of some help, too, in handling the tremendously increased volume of sales represented, has been a new procedure for filling orders. Since last April, when Association headquarters were moved, at least 95 per cent of all orders for specifications, as well as for books and reprints, have been shipped from the printer's shop in Lancaster, Pa., thus saving effort, time, and expensive storage space in New York.

Sales of reprints from the JOURNAL, at $5,868, were within $20 of last year's total. The fact that they did not increase with the increased size of the JOURNAL must be attributed primarily to the effect of the free offprints to authors.

The expense data on both specifications and reprints are rather difficult to compare or interpret in that no effort is made to allocate overhead or indirect expenses to them. Pricing policy is aimed at taking all expenses into account, and an apparent margin of $4,700 in 1956 would approximately accomplish that end.

4. Willing Water

Continuing on its bimonthly schedule in 1956, *Willing Water* contained a larger variety of material than in previous years, adding, to its public relations story, information on such subjects as research, water rights, industrial use and conservation, meter testing procedures, and civilian defense. Shifting over to the use of more papers from Association meetings, *Willing Water* included 3 conference papers and reports and 5 section meeting presentations. In this way it, too, was able to help in reducing the backlog of accepted manuscripts.

For 1957, it is expected to continue publishing in *Willing Water* those meeting papers that are particularly suited to its style of presentation, as well as to increase somewhat the information on what various utilities are doing in advertising and publicity. Tentatively, it is planned to make room for the additional coverage by the enlargement of three of the year's issues to twelve pages. This will mean a 25 per cent increase in the size of *Willing Water,* bringing it to 60 pages per year. [An appendix dealing with the expansion of AWWA's public relations program appears at the end of this report.]

As publication and mailing costs in 1956 were again below $5,000, compared with the budget of $6,000, the additional pages will not require a proportionate increase in the budget. Because of further increases in the prices of paper, envelopes, and printing, however; because of the expectation of using the more expensive offset lithography in the reproduction of case histories; and because of the continued

increase in circulation, the 1957 budget has been set at $7,000.

Sales of Willing Water public relations material—such as newspaper mats and electrotypes, posters, postal meter slugs, decals, and reprints—and of Willing Water jewelry novelties fell off during 1956 for lack of promotion. During 1957, when the new catalog of these materials is distributed, it is expected that activity will again increase.

5. Booklets

With *The Story of Water Supply* reaching the million mark in total printed, the two booklets had another banner year with a combined total sale of more than 300,000 copies. A summary of the 3-year totals of sales, costs, and income figures is presented in Table 4.

TABLE 4

Summary Data on Public Relations Booklets Through 1956

Booklet	No. Printed	No. Sold	Inventory	Production & Sales Expense $	Income $	Inventory Value $
Story of Water Supply	1,000,000	868,700	131,300	25,160.49	39,659.65	2,350.27
Your Water Supply	691,440	680,290	11,150	10,744.23	17,140.32	146.40

a. The Story of Water Supply. As the result of another promotional mailing and the continued followup of teacher requests, sales of *The Story of Water Supply* during 1956 were actually higher than in 1955, pushing up to just short of 250,000 copies. For the 200,000-copy printing during 1956, the printer increased his rates an additional 80 cents per thousand copies. This increase in basic price was absorbed without changing the sales price schedule; a concurrent boost in imprinting prices, however, necessitated a significant increase in the price of that service, to the point where it is being suggested to customers that they have their imprinting done locally.

Teacher requests for the booklet, based on its mention in educational magazines and indexes, totaled in the thousands during the year. On such requests, single copies of the booklet and the teacher's manual are supplied, and the local water superintendent is informed of the teacher's interest. Out of this followup procedure many orders have come.

b. Your Water Supply. For lack of time more than any other reason, no promotion of *Your Water Supply* was undertaken during 1956. Even without it, more than 55,000 copies of the booklet were sold, to bring its distribution up to almost 700,000. With stock just about depleted now and printing prices due to increase, plans are being made to revise the price schedule and send it out with a sample copy to all members sometime during the year. Like *The Story of Water Supply,* this booklet is not one that will become obsolete, so that its sales potential is almost unlimited.

c. What Price Water? Preliminary estimates on converting the 1950 brochure, *What Price Water?,* into a booklet of bill stuffer size indicate that it will make a booklet of at least 20 pages, which can be sold to members at prices ranging down to 3 cents per

copy if some of the costs of development—art work and plates—can be charged off to public relations activities. Because the booklet will be useful to cities promoting rate increases, every effort will be made to get it into print during the first half of 1957.

6. Books

During 1956 there was a notable and long awaited addition to the list of AWWA books; that was the JOURNAL index for the years 1940–55, which was issued late in December. The basic financial data regarding it and the other active books on the list of those sold directly by the Association are presented in Table 5. Reviewed below is the 1956 activity of each of these books and of *Standard Methods*, which is distributed by the American Public Health Assn. As will be noted, sales of all books were lower than during 1955. From all indications, this drop was due more to lack of promotion than to the added age of the volumes. [In February 1957 a direct-mail book sales sheet was distributed to all members.]

a. Manual of Water Works Accounting. Sales: 87 copies in 1956; 121 in 1955; 84 in 1954; 32 in 1953.

b. Survival and Retirement Experience With Water Works Facilities. Sales: 43 copies in 1956; 103 in 1955; 68 in 1954; 51 in 1953.

c. The Quest for Pure Water. Sales: 48 copies in 1956; 84 in 1955; 77 in 1954; 52 in 1953.

d. Water Quality and Treatment. Sales: 423 copies in 1956; 544 in 1955; 539 in 1954; 425 in 1953. With only 303 bound copies on hand at the end of the year, a new binding will undoubtedly have to be undertaken during the year.

A revision of the chapter on filtration was printed in the July 1956 JOURNAL with the expectation that reprints would be made available to all who purchased copies of the book after that date. Because criticism of one portion of that chapter as it appeared has held up action on the reprinting, the new text is not yet available. When the reprints are ready they will be offered for sale at the usual reprint prices.

e. Index to Journal AWWA (1940–55). Late in December, but neverthe-

TABLE 5

Summary Data on Current AWWA Books and Manuals

Year Published	Book	No. Printed	No. Bound	No. Sold	Inventory		Production & Sales Expense $	Income $	Value of Inventory on Hand $
					Bound	Unbound			
1938	*Manual of Accounting*	1,898	1,898	1,622	276		3,383.95	5,663.28	411.24
1946	*Survival and Retirement*	3,006	2,254	2,112	142	745	4,866.50	6,037.97	888.14
1948	*Quest for Pure Water*	2,512	2,021	1,724	297	491	8,698.90	7,391.18	1,092.90
1950	*Water Quality and Treatment* (2nd edition)	9,300	5,015	4,712	303	4,275	14,447.09	20,594.87	2,516.25
1956	*1940–55 Index*	3,500	1,500	3	1,497	2,000	4,117.69	12.60	4,126.22
	Manual								
1954	*Water Rates* (M1)	1,000	1,000	855	145		639.84	849.10	67.43
1955	*Silent Service* (M2)	5,038	2,538	355	2,183	2,500	960.92	333.82	840.14
1956	*Safety Practice* (M3)	2,000	2,000	990	1,010		919.63	1,190.25	414.10

less during 1956, the 1940–55 index was finally issued. A year-and-a-half in production, this 192-page, cloth-bound volume includes subject, author, and geographic indexes, so organized and so cross-referenced as to make literature searches simpler than in any of the previous indexes. A total of 3,500 copies were printed, but only 1,500 were bound, the balance being held in flat sheets against future demand. The price of the volume was set at $4.50, with the usual 20 per cent discount offered to members who pay cash with order.

Although the availability of the volume was announced in the December JOURNAL, no effort was made to promote its sale at the time of publication because of the fact that the bookkeeping department would have been unable to process the orders during the period when dues payments were at their heaviest. A sales sheet was prepared, however, for distribution with the February 1957 issue of *Willing Water*. It is hoped that the first binding can be sold within the first 2 years.

As shown in Table 5, only 3 copies of the new index were sold in 1956. Of the 1881–1939 volume, 13 copies were sold, leaving a balance of 94 in stock.

f. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. Sales of the tenth edition, which was published in April 1955, totaled 3,800 copies during 1956, which, added to the 7,840 copies sold in 1955, brought total distribution to 11,640 copies, more than half the total sales of the ninth edition over the 9 years of its life.

Toward the eleventh edition, the Joint Editorial Board, consisting of representatives of APHA and FSIWA, as well as AWWA, had its organization meeting in New York in November 1956, selecting F. W. Gilcreas, APHA representative, as its chairman. At that time preliminary plans for the eleventh edition were discussed and a publication target date of 1960 was set. It was also decided to establish a special committee on radioactivity to develop that section of the edition, and since then Harold Thomas of Harvard has been appointed chairman and Harold Pearson of the Los Angeles Dept. of Water & Power, AWWA's representative. Meanwhile, Michael Taras, who is AWWA's representative on the Joint Editorial Board, has been busy organizing his subcommittees and undertaking preliminary consideration of new methods.

7. Manuals

Added to the list of manuals last March, the new safety practices manual proceeded to establish itself immediately as the best seller. Its financial and sales records, together with those of the other manuals, are included in Table 5.

a. Water Rates Manual. Sales: 167 copies in 1956; 478 in 1955; 210 in 1954. With only 145 copies in stock, a new printing is scheduled for 1957.

b. Silent Service Is Not Enough! Sales: 43 copies in 1956; 312 in 1955. To help pick up the sales of this volume, it was featured in the sales sheet sent to all members in February 1957. Some explanation of its poor record undoubtedly lies in the fact that it was reprinted in full in the December 1954 JOURNAL. That should mean that its sales will improve with age, for the facts included will not become dated.

c. Safety Practice Manual. With its original printing of 2,000 copies half sold in the first 9 months and with the emphasis on safety in water utili-

ties increasing throughout the field, the safety manual promises to maintain long-term popularity. Having already reached the break-even point as far as its direct printing expenses are concerned, it also promises to be a most profitable volume.

d. Education manuals. On the basis of present estimates, it is being planned to produce over a 3-year period the six short-course manuals being prepared by the Committee on Education. It is expected that the first two of these—the courses on Water Works Management and on Water Distribution—will be ready for publication in 1957. As they will not be published first in the JOURNAL, it is intended that all costs of writing, editing, and production will be borne by the manuals. Thus, with one of the 1957 volumes estimated at 160 pages and the other at 128 pages, a budget of $5,000, to produce 2,000 copies of each, has been recommended.

APPENDIX

——Expansion of AWWA Public Relations Program——

After 11 years of public relations promotion through such activities as the development of the Willing Water bulletin, the public relations manual, the various booklets for utility distribution, the advertising electrotypes and mats of Willing Water, and the posters, decals, and postal meter slugs, the staff felt, last year, that it was time to expand these activities to provide further help to water works men—not only toward the improvement of their local public relations programs, but toward the improvement of their own lot. Toward these ends a number of possibilities were examined—and, finally, two were presented to the Executive Committee as programs that could, within the limits of the budget, be undertaken during the year 1956:

1. The provision of newspaper publicity for the meetings and activities of the Association and its sections, as well as for the speakers, awardees, committee workers, and other participants in Association affairs—with the idea of making the public more conscious of the industry as a whole, and of the importance of the local water works man in his community.

2. The provision of a series of public relations aids such as "canned" speeches, radio spot announcements, bill stuffers, news releases, and clip sheets, as well as additional posters, decals, and similar publicity materials, for the use of the local water works man in developing his own public relations program.

As originally presented to the Executive Committee, both of these possibilities included consideration of the use of professional help in conducting the program. The response of the committee was almost unanimously against the employment of professionals, on the theory that, in addition to being costly, it involved expending almost as much staff time as if the job were done internally. In favoring the use of the AWWA staff for this work, the committee endorsed the employment of additional personnel to undertake the publicity program and recommended

TABLE 6

Public Relations Activities of 454 Water Utilities

Activity	Utilities		Activity	Utilities	
	No.	%		No.	%
Talks before local groups			*Advertising* (Cont.)		
Actively promote	49	11	On radio or TV	38	8
On request	375	82	In other media	16	3
Never	49	11	No	312	61
Inform employees			*Direct-mail program*		
Employee publication	40	9	Bill stuffers	41	9
Employee meetings	234	51	Periodical bulletin	28	6
Bulletin board	161	35	Postcards or letters	52	11
Not systematically	149	33	No	368	81
Inform local officials			*Other PR techniques*		
Regular verbal reports	341	75	Annual reports to customers	49	11
By bulletin	48	11	Home shows and expositions	61	13
No	97	21	Descriptive booklets	92	20
			Window & lobby displays	53	12
School program			Other	21	5
Plant visits, regular	204	45	None	254	51
Use AWWA booklet	111	24			
Talks to classes	129	28	*AWWA PR aids*		
No	186	41	Willing Water cartoons	127	21
			Cartoon booklet	153	36
Keep local press informed			Bill stuffer booklet	68	15
Regular conferences	54	12	Postal meter slugs	33	7
Regular releases	54	12	Decals	23	5
Occasional releases	266	58	Conservation posters	35	8
Special conferences	63	14	No	217	48
Only on request	129	28			
			Most difficult PR problem		
Advertising			Support for construction project	130	29
Regularly	37	8	Support for rate increase	137	30
Occasionally	108	24	Conservation cooperation	95	10
In newspapers	123	27	Other	73	16

the postponement of the "aids" program until 1957, with the provision that a survey of the field's public relations needs be undertaken.

By converting one of the JOURNAL editors into a public relations assistant and, eventually, finding a typist to help him, the publicity program was launched in mid-September 1956 to provide publicity for the eleven section meetings that began after Oct. 15. The assistance and cooperation of section secretaries and section publicity committees was solicited, news release forms were designed and printed, a directory of newspapers in the United States and Canada was purchased, and AWWA had a publicity office.

First chore of the publicity office was finding out whom it was to publicize, and that required an advance copy of the various meeting programs. Upon

their receipt, a biographical questionnaire was sent to each section officer, awardee, and program participant to provide the basis for a release. Then as the biographies and copies or abstracts of the papers came in, releases were prepared and forwarded to all papers in the individual's home community and county—and, if the subject was of national interest, to the press associations. These releases were also sent to the section secretary and to the individual involved—with a request that they appoint themselves a clipping service to provide copies of the results.

In the rush and confusion of starting a program new to the sections and new to the personnel that was handling it, much of the program material did not arrive in time to permit followup, and many opportunities for publicity were missed, but for the eleven meetings, 100 releases were prepared and mailed out to an average of five newspapers each, and these releases were used in a considerable amount of local publicity. Just how much it is difficult to tell, for the reports from participants and from section secretaries did not provide a basis for quantitative summation, but there was enough comment from the Southwest Section, the North Carolina Section, the West Virginia Section, and the Alabama-Mississippi Section to be encouraging. And as the Executive Committee agreed to the necessity of giving such a program at least a full year's trial, there will be a better basis upon which to judge its effect next year, when there will have been an opportunity to do the advance work required for full coverage of the various meetings and other activities of the Association.

Incidentally, it should be pointed out that, as part of the publicity program, releases have been forwarded to the local newspapers of all utility men who participated in the January 1957 Board Meeting, and releases for both the newspapers and the technical press concerning the officers and awardees named there were ready to be forwarded as soon as the Board took action on the various committee reports involved.

Similarly, it is expected to give coverage to the various participants and events of the Annual Conference in Atlantic City this year, and to all other activities of the Association and its members that will be of interest to the public and that will reflect to the credit of the water works field.

Public Relations Aids Survey

In compliance with the Executive Committee's directive, a public relations questionnaire was mailed to all members with the August 1956 issue of *Willing Water,* announcing the interest of the Association in expanding its program—and asking that one person from each utility complete the questionnaire. In all, 454 utilities furnished the information summarized in Table 6.

As originally tabulated by population groups, the data showed that the large utilities were better than the small ones in their public relations accomplishments, except in the matter of keeping local officials informed. There, the more intimate contacts in the smaller communities showed to advantage. Generally speaking, the answers gave more information negatively than they did positively—that is, to say, the most impressive totals throughout were those for utilities which did nothing or almost nothing to improve their public relations. And considering that the utilities replying were undoubtedly those with the best records, it must be supposed that a large majority of water

utilities are still doing nothing positive in this field.

The last question, asking for identification of the most difficult public relations problem, produced no startling information. Among the "other" replies tabulated, every kind of problem, from delinquent accounts through fluoridation to general frustration with the public, was included, but none occurred often enough to be significant. And, to the question, "How can AWWA be most helpful?" the answers were unfortunately almost as numerous as the answerers. Of the 215 answers, however, almost half called for public relations aids of the types outlined in the AWWA program. And the fact that at least half of the 454 utilities responding to the questionnaire indicated that they had used some of the present AWWA public relations aids would seem to indicate that they are worth while.

1957 Program

In 1957, as noted above, the publicity program is to be continued, and, to provide a more accurate check upon its effectiveness, arrangements have been made with a clipping service to furnish copies of all articles printed in Canadian and United States newspapers concerning the Association and its activities. The program of public relations aids, meanwhile, is to be carried on by the present staff on a limited basis pending the report of the Public Relations Committee on the future course of the program.

Report of the Audit of Association Funds

For the Year Ending December 31, 1956

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1956 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually. Since 1942 they have appeared in the March issue.

Respectfully submitted,
HARRY E. JORDAN
Secretary

January 23, 1957

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1956, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1956, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & CO.
Certified Public Accountants

EXHIBIT A—BALANCE SHEET

DECEMBER 31, 1956

Assets

Cash in Banks and on Hand		$ 36,742.32
Accounts Receivable:		
Membership Dues	$ 312.83	
Advertising—Journal	11,248.33	
Reprints	640.71	
Sundry specifications	536.75	
The Story of Water Supply (booklet)	285.04	
Other	172.91	13,196.57
Accrued Interest on Bonds		891.69
Inventories:		
Paper stock	8,243.90	
Type metal	2,541.62	
Water Quality and Treatment (book)	2,516.25	
Manual of Water Works Accounting (book)	411.24	
Water Rates Manual (manual)	67.43	
Sundry specifications	2,681.31	
Quest for Pure Water (book)	1,092.90	
Survival and Retirement (book)	888.14	
Willing Water novelties	162.55	
Cumulative Index—1881–1939	112.80	
Cumulative Index—1940–1955	4,109.65	
Your Water Supply (booklet)	146.40	
The Story of Water Supply (booklet)	2,350.27	
Silent Service Is Not Enough! (manual)	840.14	
Safety Practice for Water Utilities (manual)	414.10	
Back Issues—Journals—Vol. 1–48, inclusive (37,614 copies)	—*	
Back Issues—Proceedings—1881–1913, inclusive (241 copies)	—*	26,578.70
Office Equipment (less depreciation)		18,275.40
Investments at Cost (Schedule 1)		161,204.00
Deferred Expenses		4,369.72
Deposit—Airlines		425.00
TOTAL ASSETS		$261,683.40

Liabilities and Surplus

Accounts Payable	$ 198.90
Membership Dues—Advance Payments	56,141.00
Unearned Subscriptions to Journal	4,902.02
Unearned Advertising	2,137.50
Payable to American Water Works Association Pension System	10,000.00†
Reserve for Award Fund (McCord)	53.02
Senior Members Contributory Fund	3,712.67
Miscellaneous	114.87
Surplus, per Exhibit C	184,423.42
TOTAL LIABILITIES AND SURPLUS	$261,683.40

* Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

† Secured by the assignment of the income of a US Savings Bond, Series G, and maturity redemption value of such bond in the amount of $10,000.00.

EXHIBIT A, SCHEDULE 1—INVESTMENTS

DECEMBER 31, 1956

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1956
Foreign Securities:				
Province of Ontario	4	$ 1,000.00	$ 732.50	$ 986.25*
Dominion of Canada, 6th Victory Loan	3	2,000.00	2,000.00	1,967.50†
Hydro Electric Power Commission of Ontario	2.75	5,000.00	5,075.00	4,337.50†
Province of Ontario	3	2,000.00	2,022.50	1,867.50†
Hydro Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,757.50†
Dominion of Canada, 9th Victory Loan	3	5,000.00	4,775.00	4,706.25†
United States Securities:				
US Savings Bonds, Series:				
G	2.5	10,000.00	10,000.00	9,790.00‡§
G	2.5	10,000.00	10,000.00	9,920.00‡
G	2.5	3,000.00	3,000.00	2,958.00‡
G	2.5	10,000.00	10,000.00	9,790.00‡
G	2.5	2,000.00	2,000.00	1,958.00‡
G	2.5	5,000.00	5,000.00	4,880.00‡
G	2.5	2,000.00	2,000.00	1,952.00‡
G	2.5	7,500.00	7,500.00	7,252.50‡
G	2.5	2,500.00	2,500.00	2,387.50‡
G	2.5	1,000.00	1,000.00	952.00‡
K	2.76	5,000.00	5,000.00	4,845.00‡
K	2.76	2,000.00	2,000.00	1,950.00‡
K	2.76	20,000.00	20,000.00	19,500.00‡
K	2.76	5,000.00	5,000.00	4,875.00‡
K	2.76	10,000.00	10,000.00	9.790.00‡
US Treasury Bills		50,000.00	49,579.00	49,658.00
		$162,000.00	$161,204.00‖	$158,080.50‖

* This security is payable in United States funds.
† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.
‡ These amounts represent redemption value on Dec. 31, 1956.
§ Redemption value and income of this security assigned to American Water Works Association Pension System.
‖ In addition to the above, the Association owns 1 share of Seymour Water Co. 6 per cent preferred stock, par value $25. This share of stock was received as a contribution in a prior year.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES

FOR THE YEAR ENDED DECEMBER 31, 1956

Operating Income:		
Annual dues	$121,690.57	
Advertising—Journal	115,640.40	
Advertising—Directory	6,556.50	
Subscriptions to Journal	9,879.19	
Convention:		
Registration fees	30,487.50	
Ticket sales	2,537.68	
Other events	117.65	
Water and Sewage Works Manufacturers Assn.	7,500.00	
Interest and dividends on investments	4,088.85	
TOTAL OPERATING INCOME (carried forward)		$298,498.34

TOTAL OPERATING INCOME (brought forward)		$298,498.34
Publication Income:		
Water Quality and Treatment (book)	1,936.92	
One-third of profit from sales of Standard Methods (book)	8,274.17	
Manual of Water Works Accounting (book)	249.77	
Water Rates Manual (manual)	180.72	
Sundry specifications	15,822.02	
Proceedings and Journals	1,439.33	
Quest for Pure Water (book)	197.25	
Survival and Retirement (book)	103.20	
Willing Water novelties	226.05	
Reprints	6,083.71	
Silent Service Is Not Enough! (manual)	52.60	
Public relations material	158.70	
Your Water Supply (booklet)	1,406.25	
The Story of Water Supply (booklet)	9,262.46	
Cumulative Index—1881–1939	21.40	
Cumulative Index—1940–1955	12.60	
Safety Practice for Water Utilities (manual)	1,190.25	
Miscellaneous	32.83	
TOTAL PUBLICATION INCOME		46,650.21
TOTAL INCOME (carried forward)		$345,148.55

Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense	$ 7,262.78		
Stenographic expense	320.80	$ 7,583.58	
Administrative Expenses:			
Rent	13,458.33		
Office supplies and services	15,071.58		
Membership promotion	1,230.08		
Pension—Secretary Emeritus	2,500.00		
Contributions to pension system	6,296.63		
Legal and auditing expenses	3,033.21		
General and special travel	1,165.19		
Federal activities	2,731.30	45,486.32	
Administrative Salaries		90,641.09	
Committee Expense		1,197.76	
Division and Section Expenses:			
Section—membership allotment	22,409.41		
Section—travel expense	5,457.95		
Section—general expense	752.22	28,619.58	
Journal:			
Printing	55,112.82		
Production	8,507.58		
Paper	19,033.26		
Abstractors	11.69		
Directory	11,190.30	93,855.65	
OPERATING EXPENSES (carried forward)		267,383.98	

TOTAL INCOME (brought forward)			$345,148.55
OPERATING EXPENSES (brought forward)		267,383.98	
Conventions:			
General	10,829.93		
Entertainment	16,480.89		
Publicity	551.70	27,862.52	
Membership Dues in Other Associations		2,384.50	
Depreciation of Office Equipment		2,155.01	
Moving Expenses		3,978.14	
Seventy-Fifth Anniversary Expenses		5,263.16	
Miscellaneous		1,684.31	
TOTAL OPERATING EXPENSES		$310,711.62	
Cost of Publications Sold:			
Water Quality and Treatment (book)	$ 753.70		
Standard Methods (book)	133.77		
Manual of Water Works Accounting (book)	155.26		
Water Rates Manual (manual)	77.62		
Sundry specifications	11,102.60		
Proceedings and Journals	24.80		
Quest for Pure Water (book)	111.32		
Survival and Retirement (book)	91.74		
Willing Water novelties	176.67		
Reprints	5,120.95		
Silent Service Is Not Enough! (manual)	11.78		
Public relations material	129.93		
Your Water Supply (booklet)	998.02		
The Story of Water Supply (booklet)	5,484.39		
Cumulative Index—1881–1939	15.60		
Cumulative Index—1940–1955	2.52		
Safety Practice for Water Utilities (manual)	826.46		
Special handling and postage charges	1,038.96	26,256.09	
Development Activities:			
Public relations	4,737.63		
Research promotion	2,325.28		
1955 Operating survey	2,182.85		
Section publicity program	729.82	9,975.58	
TOTAL EXPENSES			346,943.29
Net Income for the Year (transferred to Exhibit C)			$ (1,794.74)*

* Negative figure.

EXHIBIT C—SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1956

Balance, January 1, 1956	$186,218.16
Add: Net income for the year, per Exhibit B (loss)	(1,794.74)
Balance, December 31, 1956, per Exhibit A	$184,423.42

American Water Works Association Pension System

BALANCE SHEET—DECEMBER 31, 1956

Assets

Cash in bank	$ 1,797.64
Accrued bond interest	673.95
Investments (Schedule 1)	108,000.00
TOTAL ASSETS	$110,471.59

Liabilities and Reserve for Future Benefits

Liabilities for refund of employees' contributions plus earned interest	$ 9,792.82
Reserve for future benefits	100,678.77
TOTAL LIABILITIES AND RESERVE	$110,471.59

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1956

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions
Receipts:			
Association contributions	$ 6,296.63	$ 6,296.63	$ —
Employees' contributions	1,956.62	—	1,956.62
Interest on bonds	2,591.74	2,591.74	—
Total	10,844.99	8,888.37	1,956.62
Disbursements:			
Investment in bonds	10,000.00	—	—
Refund of contributions plus interest	420.26	—	420.26
Audit and legal expense	50.00	50.00	—
Office expenses	6.60	6.60	—
Total	10,476.86	56.60	420.26
Excess of Cash Receipts Over Disbursements	368.13	8,831.77	1,536.36
Adjustments for Non-Cash Items:			
Interest credited to employees' accounts	—	(244.74)*	244.74
Interest accrued on bonds, Jan. 1, 1956	—	(594.95)*†	—
Interest accrued on bonds, Dec. 31, 1956	—	673.95‡	—
Total	—	(165.74)*	244.74
Additions to accounts for year	368.13	8,666.03	1,781.10
Balance, Jan. 1, 1956	1,429.51	92,012.74	8,011.72
Balance, Dec. 31, 1956	$ 1,797.64	$100,678.77	$9,792.82

* Deduction.
† Accrued interest receivable as per balance sheet December 31, 1955.
‡ Accrued interest receivable as per balance sheet December 31, 1956.

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1956

Description	Interest Rate %	Principal	Maturity Date
Bonds Registered in Name of Administrative Committee:			
Series G	2.5	$ 10,000.00*	1961
Series G	2.5	10,000.00*	1962
Series G	2.5	14,000.00*	1963
Series K	2.76	9,000.00*	1964
Sereis K	2.76	17,000.00*	1965
Series K	2.76	9,000.00*	1966
Series K	2.76	9,000.00*	1967
Series K	2.76	5,000.00†	1968
Series K	2.76	10,000.00†‡	1968
Series K	2.76	5,000.00†§	1968
Bond Registered in Name of Association and Assigned to Administrative Committee:			
Series G	2.5	10,000.00	1958
Total		$108,000.00	

* Redemption value on Dec. 31, 1956: $80,317.00.
† Acquired in 1956.
‡ Not redeemable until May 1, 1957.
§ Not redeemable until Jun. 1, 1957.

1956 Section Membership Awards

Old Oaken Bucket		Hill Cup		Henshaw Cup	
Section	Score*	Section	Score†	Section	Score‡
California	1,349	Indiana	48.365	Cuban	84.6%
Southwest	1,058	Iowa	24.444	Rocky Mountain	82.9
New York	834	Nebraska	23.551	Montana	64.8
Canadian	642	California	19.505	Iowa	53.0
Illinois	567	North Carolina	18.612	North Carolina	51.7
Pennsylvania	544	Southwest	18.018	Michigan	48.3
Indiana	476	Arizona	16.800	Ohio	47.7
Ohio	473	Kentucky-Tennessee	15.226	Alabama-Mississippi	47.0
New Jersey	448	Pennsylvania	13.448	Southeastern	46.8
Pacific Northwest	432	Montana	13.320	Wisconsin	45.2
Michigan	416	Rocky Mountain	13.305	California	43.4
Florida	334	Illinois	12.920	North Central	43.1
Southeastern	284	North Central	12.122	Pacific Northwest	42.9
Chesapeake	260	Missouri	11.296	Nebraska	42.7
North Central	255	Virginia	10.933	Kansas	42.2
New England	241	Southeastern	10.695	Kentucky-Tennessee	41.6
Kansas	223	Ohio	10.332	Southwest	41.3
North Carolina	220	New Jersey	10.325	Virginia	41.1
Kentucky-Tennessee	219	Pacific Northwest	9.666	West Virginia	39.4
Missouri	216	Michigan	9.366	Chesapeake	38.6
Alabama-Mississippi	210	Wisconsin	8.734	Indiana	36.7
Virginia	202	Chesapeake	7.080	Arizona	35.1
Wisconsin	194	New England	6.732	Florida	31.5
Rocky Mountain	182	Alabama-Mississippi	6.432	Pennsylvania	29.8
Iowa	153	Canadian	3.720	Canadian	‖
Nebraska	106	West Virginia	3.098	Illinois	‖
West Virginia	98	New York	2.784	Missouri	‖
Arizona	79	Cuban	2.718	New England	‖
Montana	56	Kansas	1.110	New Jersey	‖
Cuban	49	Florida	§	New York	‖

* Numbers of members.
† Weighted gain in membership.
‡ Percentage of members present at annual meeting.
§ Minus score.
‖ Data not available or section not competing.

AWWA Membership Growth

Membership Statement—Year of 1956

	Active	Corporate	Munic. Serv. Subscriber	Associate	Honorary	Junior	Affiliate	Total
Total members, Dec. 31, 1955	8,787	918	239	351	42	45	44	10,426
Change of grade, 1956	7	−1	1		4	−10	−1	
	8,794	917	240	351	46	35	43	10,426
Gains:								
New, 1956	1,292	60	30	20		21	1	1,424
Reinstated, 1956	112	3		3				118
	10,198	980	270	374	46	56	44	11,968
Losses:								
Resignations and deaths, 1956	−249	−17	−3	−6	−5	−1	−3	−284
Dropped for nonpayment, 1956	−534	−41	−21	−4		−5	−6	−611
TOTAL MEMBERS, Dec. 31, 1956	9,415	922	246	364	41	50	35	11,073
Net gain in 1956	628	4	7	13	−1	5	−9	647

Comparative Statement—Gains and Losses—25-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1932	117	22	169	297	327−	2,390
1933	168	56	159	234	169−	2,221
1934	271	66	86	122	129+	2,350
1935	565	42	85	190	332+	2,682
1936	311	53	104	218	42+	2,724
1937	515	86	122	139	340	3,064
1938	520	59	144	140	295+	3,359
1939	578	64	122	179	351+	3,710
1940	514	58	113	212	247+	3,957
1941	480	92	116	236	220+	4,177
1942	570	59	132	233	264+	4,441
1943	769	88	130	198	529+	4,970
1944	734	92	140	171	515+	5,485
1945	543	56	111	235	253+	5,738
1946	816	79	168	324	403+	6,141
1947	933	74	143	349	515+	6,656
1948	847	81	207	347	374+	7,030
1949	1,083	75	196	323	639+	7,669
1950	852	58	128	421	361+	8,070
1951	1,090	63	199	441	513+	8,583
1952	1,005	66	232	505	334+	8,917
1953	1,077	99	263	370	543+	9,460
1954	1,160	69	256	493	480+	9,940
1955	1,244	90	270	578	486+	10,426
1956	1,424	118	284	611	555+	11,073

Palatable Water Means Good Public Relations

The severest critic of the palatability of a water supply can be the casual visitor—tourist or salesman, because he can compare your supply with that of other communities. Ill-tasting water can also influence industries against settling in your town. Every water works official should strive to satisfy the severest critic, thereby, pleasing the local consumers as well. Adequate usage of Nuchar activated carbon will assure delivery of a palatable water at all times, so that when your local consumers go travelling, they will return with that wonderful feeling—"There's no place like home."

AQUA NUCHAR ACTIVATED CARBON'S adsorptive ability covers a wide range of taste- and odor-producing bodies. John R. Baylis has stated "All tastes and odors likely to be present in a water supply can be removed with activated carbon. We find a few statements in the literature on water treatment that the taste or odor was not removed by the addition of carbon, but almost invariably the reason was that not enough carbon was used."

GOOD CARBON · GOOD WATER · GOOD WILL

New York Central Building
230 Park Ave., New York 17, N. Y.
Phila. Nat'l Bank Bldg.
Broad & Chestnut Sts., Phila. 7, Pa.

industrial CHEMICAL SALES
division west virginia pulp and paper company

Pure Oil Building
35 E. Wacker Drive, Chicago 1, Ill.
2775 S. Moreland Boulevard
Cleveland 20, Ohio

there's a cost that stays *Sealed* for seven years

All water meters are fine instruments. Any fine instrument loses accuracy as it wears. Because of this fact, written between the lines of any water meter price are two items you can't read for many years. Yet they are vital in choosing the lowest "total price."

First, as a meter loses accuracy, it gives away revenue. Before its first overhaul it may give away twice as much money as it seems to save in its "low bid" original price.

Secondly, to keep the meter accurate you may have higher repair costs over the years . . . or premature scrap-and-replace costs. Good meters often vary widely in this respect.

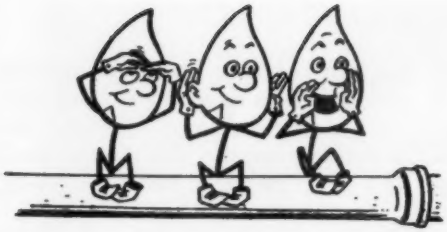
Tridents are preferred because they earn more and cost less in the long run. They never become obsolete. You modernize your Tridents as you repair. Ask your neighbor . . . or ask Neptune for details.

neptune

NEPTUNE METER COMPANY
19 West 50th Street • New York 20, N. Y.

NEPTUNE METERS, LTD.
1430 Lakeshore Road • Toronto 14, Ontario

Branch Offices in Principal American and Canadian Cities



Percolation and Runoff

The onwardness and upwardness of AWWA was never more manifest than it was last Jan. 27–29, when the Association's Board of Directors got together in the tower rooms of the Park-Sheraton Hotel in New York to review the year's accomplishments, to plan for the future, and to conduct such business as required Board action. Not just a growth in numbers or in dollars or even in activities, but a growth in outlook was apparent as the directors spent the hours from noon on Sunday to noon on Tuesday in almost continuous session to cover some 40 items of business. And no item was more indicative of the new outlook than the adoption of a program of certification of the products and services provided under AWWA specifications. Although a number of the details remain to be worked out and although the initiation of the program will require a careful review of all 60 of the Association's present standards, it is expected that the AWWA seal will begin appearing on water works equipment by the first of 1958 and that the list of those licensed to use that seal will grow rapidly as water works men come to recognize its value. The Board took some notable onward and upward looks, too, in the fields of research and public relations. A good review of AWWA's activities along research lines appeared in the December 1956 issue of *Willing Water* and a look at the public relations picture is taken on pages 357–60 of this issue. Meanwhile, reports of other Board business also appear in this issue beginning on page 331.

Onward and upward, too, was the direction of a whole host of new officers and awardees there nominated or named: for next prexy, Fred Merryfield; for veep, Lew Finch; for new Dollar Bill, Bill Orchard; for treasurer emeritus, after 33 years of pre-emeriticism, Bill Brush; and for the 1957 awards:

Honorary Membership: Albert E. Berry, Charles H. Capen, S. Logan Kerr, W. A. Kunigk

Diven Medal: John H. Murdoch Jr.

Goodell Prize: Thurston E. Larson

Division Awards: Distribution—Jack W. MacKay; Management—Louis R. Howson; Purification—John R. Baylis; Resources—Warren J. Kaufman and Gerald T. Orlob

Harry E. Jordan Scholarship Award: Herbert H. Hassis, Clarkson College, $1,000; Wilbert H. Schlimmeyer, Rutgers University, $500.

And onward and upward again went the safety program with the establish-

(*Continued on page 42 P&R*)

(Continued from page 41 P&R)

ment of a new system of Section and Association safety awards, the Board naming the latter the Wendell R. LaDue Safety Awards in recognition of Wendell's inspiration and leadership of the AWWA program.

As a matter of fact, there was hardly time for anything backward and downward at all. Except for a few moments of levity after Sunday dinner, a time out or two to enjoy the Florida Section citrus and the West Virginia Section apples, a cocktail courtesy of the about-to-become-lame-duck members of the Board, and a few choice remarks here and there, the only opportunity that presented itself was the Monday evening recess. And with the New York Section cocktail party getting that under way in the Rainbow Grill on the 65th floor of the RCA Building, it could hardly be called downward—nor was anyone notably backward. What backsliding or downfalling there was for the balance of the evening could probably be blamed on the ice that slicked up the city and suburbs. At any rate, all were up and on hand when the Tuesday morning session began and uppermost and honormost at the New York Section luncheon meeting which followed the Board's noon adjournment.

Onward, now, to Atlantic City, where upwards of 2,500 of the Board's constituents will be on hand to help keep AWWA on target.

'Upwards of 2,500' by the way, is not just a guess. It is a careful estimate obtained by the scrupulous application of standard statistical methods to data financially guaranteed to be as accurate as humanly possible. In other words, it is an estimate based on averaging the figures dropped into the convention registration pool by the directors and their wives. Average—mean, we mean—of the $72 worth of predictions was 2,507; median was 2,525; mode was 2,496; and the range was 2,002 to 2,800. With St. Louis last year at 2,536, Chicago the year before at 2,587, and Bill Brush, a three-time pool winner, at 2,800, we're putting the accent on *upwards*. And upwards on the Jersey coast is where all AWWA and its wives ought to be heading—for arrival May 12! (See p. 52 P&R for preliminary program.)

Public health traineeship applications are now being accepted for next fall and should preferably be submitted to the US Public Health Service by Apr. 1. Under the program instituted last year, traineeships (graduate or specialized only, *not* basic professional preparation) are available to all categories of professional public health personnel. Preference is given to qualified individuals under 35 with no more than 2 years of experience in public health work and less than a year of graduate or specialized training. These are not hard-and-fast criteria, however, and other relevant factors will be considered. The 12-month stipend ranges from $2,400 to $4,800 (depending on academic degree held), plus allowances for dependents and tuition. Application forms and additional information may be obtained from: Chief, Div. of General Health Services, Bureau of State Services, Public Health Service, Washington 25, D.C.; or from regional USPHS offices.

(Continued on page 44 P&R)

New Recarbonator Principles

provide GREATER EFFICIENCY in MUCH LESS SPACE

Revolutionary new water stabilization system with control panel can be designed to meet your requirements.

Proved in actual service, this development by INFILCO engineers offers you many advantages in CO_2 generation and distribution.

Since the burner and combustion chamber are located in the top of the "downcomer," the lower portion of which is immersed in the recarbonation basin water itself, costly cooling apparatus is eliminated. There are no exposed hot gas lines.

You get greater efficiency from less than 1/3 the space required by the old-style systems. Complete combustion gives clean gases in exact quantities — no need for scrubbing. Corrosive effect of gases is reduced. Proper controls make operation safe, simple and subject to visual check. Scaling from calcium carbonate and magnesium hydroxide is minimized.

Only INFILCO engineering and equipment give you all these advantages.

Facilities are available throughout the nation to help you solve your problem. Write today for complete details.

COMPLETE COMBUSTION

Typical control panel, indicating simplicity of operation and control

INFILCO INC.
Tucson, Arizona

The ONE company offering equipment for ALL types of water and waste treatment

INFILCO

FIELD OFFICES IN PRINCIPAL CITIES IN NORTH & SOUTH AMERICA

5609

(Continued from page 42 P&R)

Durando Miller has been appointed technical manager by The Permutit Co., New York. He has been assistant technical manager since 1953.

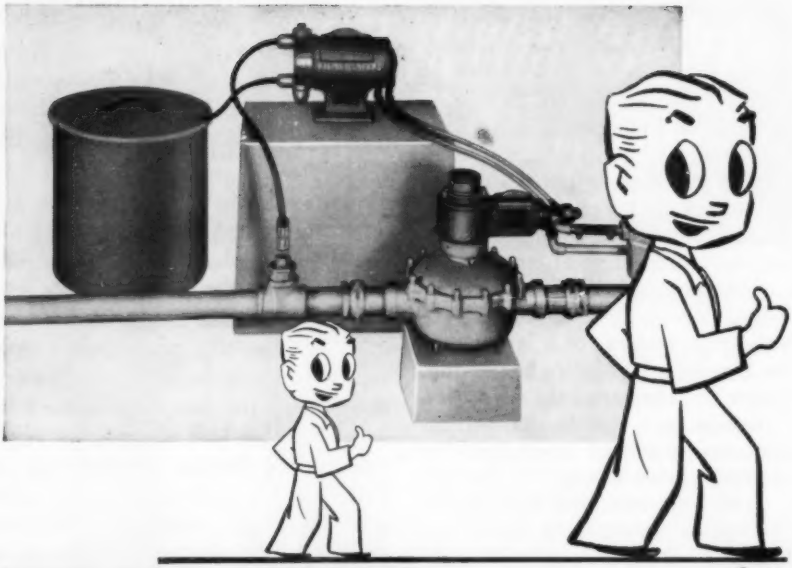
The Beavers, an organization of the heavy-engineered construction industry west of the Mississippi, have honored AWWA Member Robert B. Diemer, general manager and chief engineer of the Metropolitan Water Dist. of Southern California, Los Angeles, with a "Golden Award" for outstanding contributions to the industry. The award was presented at a dinner on Jan. 17, at which the principal speaker was former AWWA President Abel Wolman, professor of sanitary engineering at Johns Hopkins.

Stephen C. Casteel is retiring as manager of East St. Louis & Interurban Water Co., East St. Louis, Ill. His successor will be Frank J. McAndrew, presently manager of St. Joseph (Mo.) Water Co. Replacing McAndrew is E. C. Smith, formerly assistant general manager, Birmingham, Ala., Water Works Board.

J. Henry Rushton, professor of chemical engineering, Purdue University, has been named president of American Institute of Chemical Engineers. The new vice-president is George E. Holbrook, assistant general manager of du Pont's Organic Chemical Dept.

Robert B. Diemer (left) receives Golden Award from Beaver President L. E. Dixon.

(Continued on page 46 P&R)



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Simple and dependable, the Chem-O-Feeder is paced by a standard main line, by-pass, or fire line meter — and is easily adapted to most any meter already in service. The meter does not drive the pump but serves simply as a control unit — thus the accuracy of the meter itself is in no way impaired. Bulletin SAN-6 gives complete details . . . send for your copy today. Proportioneers, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

PROPORTIONEERS, INC.
DIVISION OF
B-I-F INDUSTRIES
PROVIDENCE, RHODE ISLAND
METERS FEEDERS CONTROLS

(Continued from page 44 P&R)

Law and order is the news in fluoridation these days—the law being made in Manitoba and the order in California as new means of instituting the procedure.

At Winnipeg, addition of fluorides was begun last Dec. 28 after approval of the practice had been obtained from "at least five of the nine member municipalities representing at least 85 per cent of the population" of the Greater Winnipeg Water Dist., in compliance with the requirements of a law passed by the Manitoba legislature last spring. Although the characteristic opposition was present and still is, its current effectiveness has been neutralized by the waiting period incorporated in the law, which provides that fluoridation can be voided only after a 5-year period on application of four municipalities representing 20 per cent of the district's population.

At Oroville, Calif., meanwhile, fluoridation will soon be initiated by the California Water Service Co. by order of the California Public Utilities Commission. Previously, the company had refused to fluoridate—despite official requests that it do so by both the city of Oroville and the county of Butte—contending that it could take such action only after a vote of its customers. In a suit filed with the commission, the city and county were joined by a number of other organizations, while the company received the support of various fluoridation opponents. The decision, undoubtedly the first in which a privately owned water utility has been required to fluoridate, made a point of the fact that "the action . . . is not to be understood as holding that a water public utility which

(Continued on page 48 P&R)

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Sodium Fluoride—98%

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Meet AWWA specifications

White or tinted blue
Minimum of dust in handling
Minimum of storage space
Available in bags and drums

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VALVE COMPANY

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Oskaloosa, Iowa

(*Continued from page 46 P&R*)

does not fluoridate its water supply, necessarily, is violating the law."

By law or order, but not by referendum, seems to be the trend these days in fluoridation decisions. Thus, at New York, where the city authorities have apparently been unable to make up their minds after several years of study, restudy, recommendation, argument, hearing, and report, the idea of a referendum has been rejected as unwise as well as illegal. And at Detroit, where the board of water commissioners has already acted against fluoridation, the city council also turned down a proposal to submit the decision to the voters. Even where city authorities have asked the voters to express themselves on the subject, the expressions have usually been accepted as advisory rather than compulsory, with the teeth put in by law or order.

Fluoridation, which continues to make our mailbag bulge—the bulge of the battle between its pro- and its opponents—seems to be belaboring our British counterparts as well. Thus, in listing on the contents page of the November 1956 *British Waterworks Association Journal* an article with subitems on "Conflicting Opinions Voiced at Meeting" and "The Gentleman in Whitehall Knows Least," the editor wrote "Effect of Fluoridation Upon the Yield of Water Catchment Areas. By Frank Law." Of course, it may have been salesmanship rather than free association, but we doubt that he would thus risk the wrath of those interested in "Afforestation." No, this must be further proof of the fact that fluoridation has lost editors more teeth through gnashing than it will ever save their children.

(*Continued on page 78 P&R*)

IRON REMOVAL & WATER SOFTENING

During 1956 we built a large number of durable and efficient low cost water treating plants for the removal of iron, manganese, hardness and other undesirable impurities. These plants operate *automatically*, require very little space and are unusually inexpensive to operate and maintain.

Full Particulars on Request

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The meter used by thousands of municipalities in the U. S.

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

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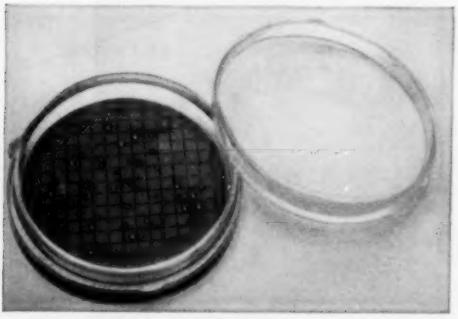
Water Testing

*APPROVED Water Pollution Control Technique

in the Laboratory

with the MILLIPORE FILTER STANDARD METHOD

NOW APPROVED as an alternate Standard Method for coliform testing, the MILLIPORE FILTER technique allows the determination of potable water quality to be carried out more RAPIDLY, more ECONOMICALLY, and with much greater ACCURACY than ever before possible. Results are obtained up to 5 times faster—in 16 to 20 hours—and with 2 to 5 times the precision of present broth tube methods. No tubes to wash, no breakage problems—the MF® technique saves valuable time, saves money, saves space.



MILLIPORE FILTER in Disposable Plastic Petri Dish showing typical Coliform Bacteria Sheen Colonies, indicative of water contamination. MF® incubated for only 18 hours at 35°C.

MILLIPORE FILTERS are conveniently packaged in resealable Kraft envelopes—10 filters and nutrient pads per envelope—ready for immediate autoclave sterilization. Grid-marked to facilitate colony counting, the MF® may be readily filed as a permanent record of test results.

REGULATIONS SENSIBLY REQUIRE THAT PARALLEL TESTING OF THE MF® TECHNIQUE AND PRESENT METHODS be conducted in each laboratory to assure results of equivalent sanitary significance before adopting the new Standard Method. Full details on establishing MILLIPORE FILTER techniques in your laboratory are immediately available upon request.

Write for a copy of the new color-illustrated booklet,
"The MILLIPORE FILTER Standard Method of Water Bacteriology."

WATER TESTING IN THE LABORATORY — IN EIGHT STEPS

1. Media prepared.
2. Filters autoclaved.
3. Approximately 2 ml of medium added to pad.
4. Filter placed on holder.
5. Funnel clamped.
6. Sample poured and vacuum applied.
7. Filter "rolled" onto pad. Avoid trapping air between filter and pad.
8. Dishes covered and incubated 20 hours in inverted position.

MILLIPORE FILTER CORPORATION

36 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS, U.S.A.

Water Testing

*APPROVED Water Pollution Control Technique

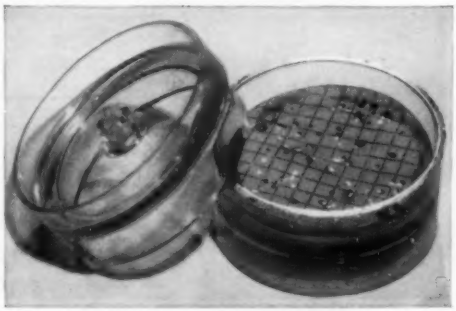
in the Field

with the MILLIPORE FIELD MONITORING KIT

EMPLOYING THE BASIC MILLIPORE FILTER TECHNIQUE, now approved as an alternate Standard Method for coliform testing, the FIELD MONITORING KIT yields accurate, direct field determinations of the bacterial content of waters in 18 to 20 hours. Used in conjunction with the Millipore Field Incubator, the FIELD MONITORING KIT is particularly adapted for use in rural areas or under disaster conditions where laboratory facilities are unavailable. In use by the World Health Organization, the FIELD MONITOR has also been recommended by the U. S. Navy for use by its Preventive Medicine Units.

SUPPLIED STERILE and ready for use, the FIELD MONITORING KIT contains two disposable plastic Monitor units which serve as combination filter holders and culturing dishes, two ampules of liquid nutrient medium, and two plastic sampling tubes. The Kit is packaged in a convenient mailing box to allow easy shipment if desired.

THE FIELD MONITORING KIT allows the sampling of large volumes of water, eliminates the cost and inconvenience of sample shipments in glass bottles, and requires no laboratory facilities. It is FAST, ACCURATE, REPRODUCIBLE AND ECONOMICAL.



FIELD MONITOR top removed to show Coliform Bacteria Sheen Colonies developed on the MF® surface after 18 hours of incubation.

Write for a copy of the new color-illustrated booklet,
"The MILLIPORE FILTER Standard Method of Water Bacteriology."

WATER TESTING IN THE FIELD — IN EIGHT STEPS

1. Cup, thoroughly rinsed.

2. Sample drawn through Monitor in inverted position.

3. Monitor righted for last drops.

4. Ampul tip broken — ampul inserted into Monitor.

5. Ampul tip broken — ampul lifted slightly.

6. Media drawn through Monitor with syringe. STOP THE INSTANT last few drops of media disappear.

7. Replace caps.

8. Incubate 20 hours in inverted position.

MILLIPORE FILTER CORPORATION

36 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS, U.S.A.

Atlantic City Technical Program

MONDAY MORNING, May 13

Water Works Administration Committee—Open Session

Progress Reports of Committees
- Joint Administration of Water and Sewage Facilities....L. N. Thompson & R. J. McLeod
- Water Main Extension Policy....L. S. Finch
- Revenue-producing Water....E. Shaw Cole
- Rating Scale for Water Works....John H. Murdoch Jr.
- Safety Practices....R. J. Faust
- In-Service Training....R. J. Faust
- Publicity Program....E. L. Filby
- Air Conditioning....E. L. Bean

Water Resources Division

Impounding Reservoirs
- Land Policy....Francis S. Friel
- Public Access Policy....Daniel P. Morse
- Discussion....E. S. Chase

Honolulu Water Supply....Edward J. Morgan

MONDAY AFTERNOON, May 13

Water Distribution Division

Automatic Control in Distribution Systems
- Philadelphia....V. A. Appleyard
- Long Island Water Co....S. C. McLendon

Concrete Pipe Corrosion....Martin E. Flentje & Robert J. Sweitzer

Water Hammer Allowances in Pipe Design....S. Logan Kerr
- Discussion....Vance C. Lischer, Fred G. Gordon & John H. Murdoch Jr.

Water Resources Division

Saline Water Conversion....David Jenkins
- Discussion....S. T. Powell

Reservoir Evaporation Control....Lloyd O. Timblin Jr.

Salt Water Intrusion....H. H. Cooper Jr.

TUESDAY MORNING, May 14

Water Works Practice Committee—Open Session

Progress Reports of Committees
- Butterfly Valves....Fred G. Gordon
- Gate Valves....David Auld, L. E. Tabor & Leslie Paul
- Meters....James G. Carns

Water Purification Division

Handling Liquid Alum....James E. Kerslake
- Discussion....Oscar Gullans, Norman E. Jackson, Richard Ockershausen, David Lurie & Leo Louis

Panel Discussion—Experiences in Applying Fluorides....*Led by* John R. Baylis, E. L. Bean, A. A. Bailey & W. B. Schworm

(*Continued on page 54 P&R*)

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Automatic Valves

ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

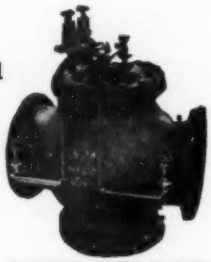
SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

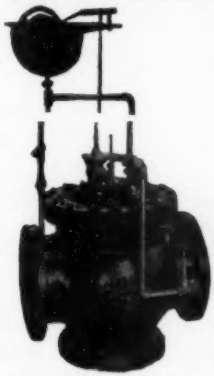
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.



FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished

REMOTE CONTROL VALVE

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(*Continued from page 52 P&R*)

Carbonation of Water Softening Sludge.....F. A. Eidsness
Discussion.....F. G. Nelson
Panel Discussion—Safe Handling of Chemicals.....*Led by* Jerome C. Zufelt, Lee Streicher, Peter Pallo & L. L. Hedgepeth

TUESDAY AFTERNOON, May 14

Water Resources Policy and Development—General Session

The Oregon Water Law.....Fred Merryfield
New Jersey Water Supply Development.....*Governor* Robert Meyner
W. H. Baumer & Charles H. Capen
The California Plan.....M. J. Shelton

WEDNESDAY MORNING, May 15

General Session

AWWA Specifications and the Certification Program.....Frank C. Amsbary Jr.
AWWA National Water Policy.....Abel Wolman
Water Works Planning in Great Britain.....G. M. Binnie
Panel Discussion—Highway Relocation Problems.....S. S. Anthony, J. J. Barr, E. A. Bell, E. W. Clark, Thomas W. Moses, H. B. Shaw & A. R. Vollmer

WEDNESDAY AFTERNOON, May 15

Four Division Meetings—Program to Be Announced

THURSDAY MORNING, May 16

Water Distribution Division

Service Buildings.....L. S. Finch
Service Trucks.....Fred D. Jones
Panel Discussion—Setting Meters.....*Led by* W. Victor Weir, G. E. Arnold, James G. Carns, W. E. MacDonald & Marsden Smith

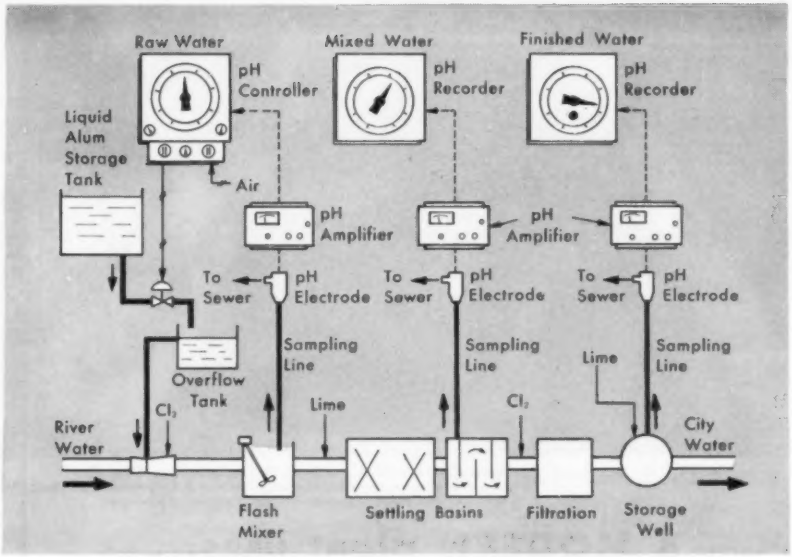
Water Purification Division

The Jar Test—A Review.....A. P. Black
Coagulant Aids.....J. M. Cohen
Special Culture Media.....Gilbert V. Levin
Automation and Remote Control of Chemical Feeders.....Paul Coffman

THURSDAY AFTERNOON, May 16

Management Division—General Session

Current Experiences With Revenue Bonds.....D. L. Erickson & George L. McKelvey
Wisconsin's Policy on Municipal Utility Taxation.....A. P. Kuranz
Problems in Personnel Recruiting.....Milton Rosen
Panel Discussion—Water Utility Earnings.....*Led by* L. R. Howson, Burton S. Grant, M. H. McGuire, E. M. Hawkins Jr., H. J. Graeser, Claud R. Erickson & M. B. Whitaker



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With the replacement of a manually-regulated chemical feed system at the Macon, Ga. Water Works by Honeywell automatic controls, alum and chlorine consumption is reduced by half. These controls reduce turbidity from nine to 1.5 parts per million, doubling filter plant capacity. Red water is eliminated, with a saving of more than 200,000 gpd in blow-off water.

Brown *ElectroniK* pH instruments cut chemical costs by 50 percent, double filtration capacity, and save 200,000 gpd of blow-off water.

One *ElectroniK* recorder-controller measures and maintains the pH of water in the flash mixer at the most efficient coagulation value, by automatically adding liquid alum to raw water. Two other instruments measure and record pH of treated and finished water.

For the economical solution to your own water treatment problems, call your nearby Honeywell sales engineer. He's as near as your phone.

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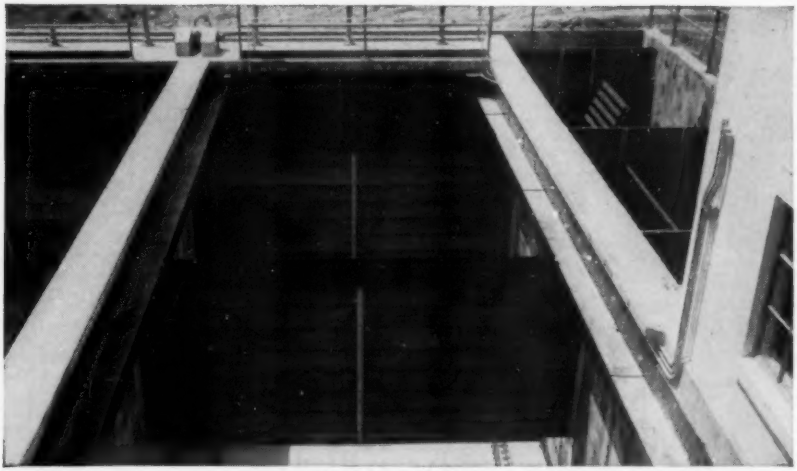
First in Controls



Rex Floctrol and Verti-Flo at Boro of Somerset, Pa., Filter Plant.
Consulting Engineers: Gannett, Fleming, Corddry & Carpenter, Harrisburg, Pa.
L. J. Whipperman, Plant Operator. Richard Pyle, Boro Manager.

A MODERN plant uses... MODERN equipment

Here's just one of the many *modern* plants using *modern* Rex equipment: Boro of Somerset, Pa., filter plant with Rex Verti-Flo, Rex Floctrol and Rex Flash-Mixer.

1 **Rex Verti-Flo.** Unique design divides the conventional horizontal settling tank into a series of smaller, vertical-flow cells. Results: greater tank capacity, up to four times more... detention times from one quarter to one half those of conventional tanks with effluent of maximum clarity. Greater capacity means future savings as the plant load increases... savings in construction, equipment, operating and maintenance costs.

2 **Rex Floctrol.** Exclusive combination of mixing paddles, rotating baffles and fixed partition walls assures full utilization of tank volume... minimum amount of chemical used... large, readily settleable floc. Result: greater efficiency. Smaller basins are used ...again saving in construction and operating costs.

3 **Rex Flash-Mixer.** Double-mixing action combines slow rotation with rapid top-to-bottom turnover for most thorough mixing. Results: almost instantaneous dispersion of chemicals... greater efficiency... increased over-all plant capacity.

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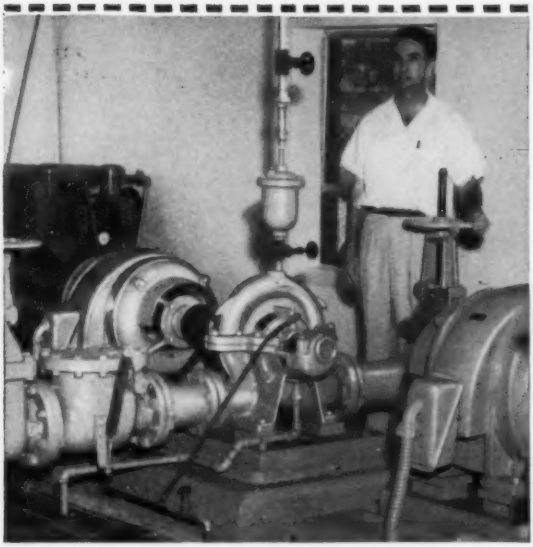

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Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

HYDRAULICS

Some Hydraulic Aspects of Sewerage and Sewage Disposal. C. B. TOWNSEND & G. W. WILKINSON. Proc. Inst. Civil Engrs. (Br.), 4:662 (Dec. '55). Object of paper is to indicate that sequence of operations in sewers and at treatment works depends for their proper functions on sound application of hydraulic principles to ensure both efficient transport of solids and their removal, or differential removal, at various stages required. Need for further research is emphasized. Paper considers various problems in sewerage practice from British viewpoint, such as veloc. formulae for flow in pipes; effect of sewage conditions on design; states of flow: sewer junctions and drop-pipes; sideweir overflows. In sewage disposal, control of veloc. and levels is discussed, and separation of suspended solids, grit chambers, sedimentation tanks (with comment on limitations of Hazen's theory), effect of inlet and outlet conditions; distr. of flow among units.—*PHEA*

Water Hammer Due to Changes in Velocity in Service and House Lines. W. E. A. DEK. Water (Neth.), 39:13 (Jan. '55). Author discusses eqs. used for calcn. of water hammer. Type of material used for construction of metal pipes has little influence on water hammer but various sorts of plastic can reduce magnitude of water hammer to 15–30% of that which would occur in similar metal pipes. Asbestos cement pipes give results similar to metal pipes of same length.—*PHEA*

Nomographs for the Determination of Head Loss in Round Pipe. A. DE KRUYFF. Water (Neth.), 39:135 (May '55). Author discusses use of a nomograph for computing head loss in round pipes. Nomograph with directions for use are given.—*PHEA*

Measurement of Delivery in Venturi Canals. GUYARD & MIGNOT. L'Eau (Fr.), 42:131 (Jun. '55). Continuing a discussion of measurement of delivery of potable water supplies in rural areas, authors present designs for delivery and formulae for flow data in Venturi canals.—*PHEA*

Bedding and Backfilling Methods Save Reinforcing in San Diego Aqueduct. R. E. SAILER. Civ. Eng., 25:38 (May '55). Second barrel of San Diego Aqueduct was constructed after careful design based on hydraulic gradients, hydraulic and earth pressures, backfill methods, and blowback conditions. Bulb-like earth and load pressures were assumed in design. 2 methods of bedding were used: consolidated backfill bedding and compacted backfill bedding. Except for special cases the consolidated backfill bedding was more economical so that it was used wherever possible. When 30% slope was exceeded, compacted backfill bedding was used. Allowable pipe stresses were increased over that used in line built in 1947 due to use of steel sheet with much higher yield point. Blow-backs due to entrained air following hydraulic jumps were prevented by proper hydraulic design utilizing basic work done by Kalinske and Robertson. This involves use of Froude number plotted against ratios of water depths to pipe diameters.—*PHEA*

The Control of Delivery in the Supply of Potable Water to Rural Areas. E. GARDET. L'Eau (Fr.), 42:51 (Mar. '55). First portion of article is given over to study of measure of delivery in open canals. Formulae are presented in gauging flow through canals with or without lateral contractions and in canals with triangular shape. Additional data are given for Venturi canals, measurement of depth and by method in which Pitot-Darcy tubes or hydrotachymeters are used.—*PHEA*

(*Continued on page 65 P&R*)

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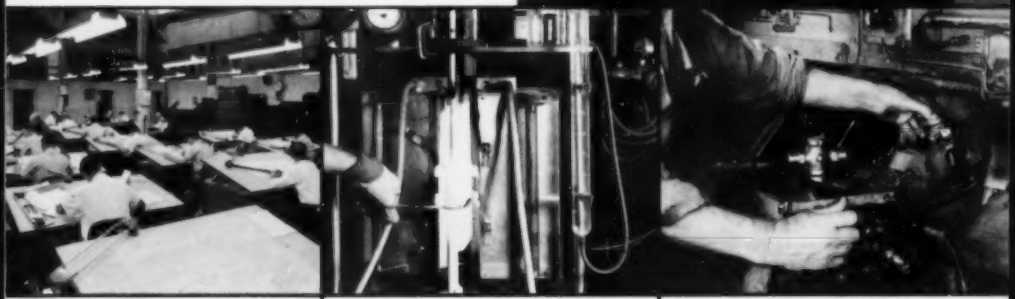

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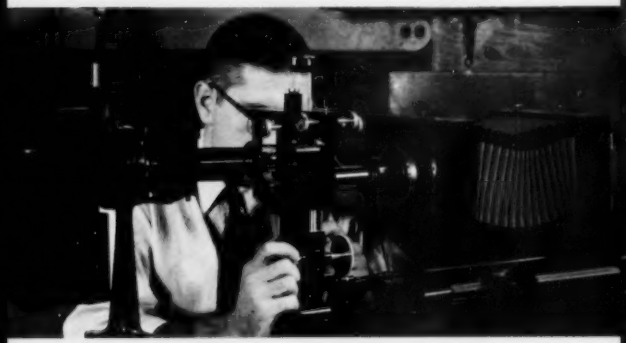

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(Continued from page 64 P&R)

Weirs With Linear Variation and Constant Quantity Sensitivity. P. MORIN. L'Eau (Fr.), **42**:195 (Aug. '55). Author describes portable weir and gives formulae and data showing its usefulness in measuring stream flow.—*PHEA*

FLUORIDATION

Chronic Fluorine Intoxication From Drinking Water. G. L. WALDBOTT. Intern. Arch. Allergy and Appl. Immunol., **7**:70 ('55). It is suggested that allergic patients have abnormally low tolerance to drugs, etc. Fluoride 1 ppm in public water supply was found to be cause of severe symptoms of toxicity in asthmatic subject.—*PHEA*

The Fluoridation of Water Supplies—Its Value and Safety. J. H. C. CLARKE. J. Brit. Water Wks. Assn., **37**:664 ('55). After outlining most important findings establishing relation between fluoride content of water supplies and degree of dental caries and fluorosis, author indicates advantages of use of water for administering fluorides and examines evidence in support of value and safety of fluoridation of water supplies. Particular reference is made to results obtained from fluoridation programs carried out in USA, and to effect of naturally-occurring waters with high fluoride content on dental caries. Arguments advanced by opponents of fluoridation, and answers thereto, are considered. Practical aspects of technique of fluoridating water supplies are given in appendix.—*WPA*

Fluoridation of Water Supplies. Stadtehygiene (Ger.), **6**:222 ('55). After consideration of problems, especially legal, of treatment of water supplies by fluorine, Deutsche Verein von Gas- und Wasserfachmannern publishes conclusions which include following. Though reduction of caries by presence of certain concn. of fluorine in water is possible, addition of fluorine to water supplies is not only way of achieving this object, so that treatment with fluorine cannot be claimed to be essential. Legal position and risks of using water supplies in this way are pointed out.—*WPA*

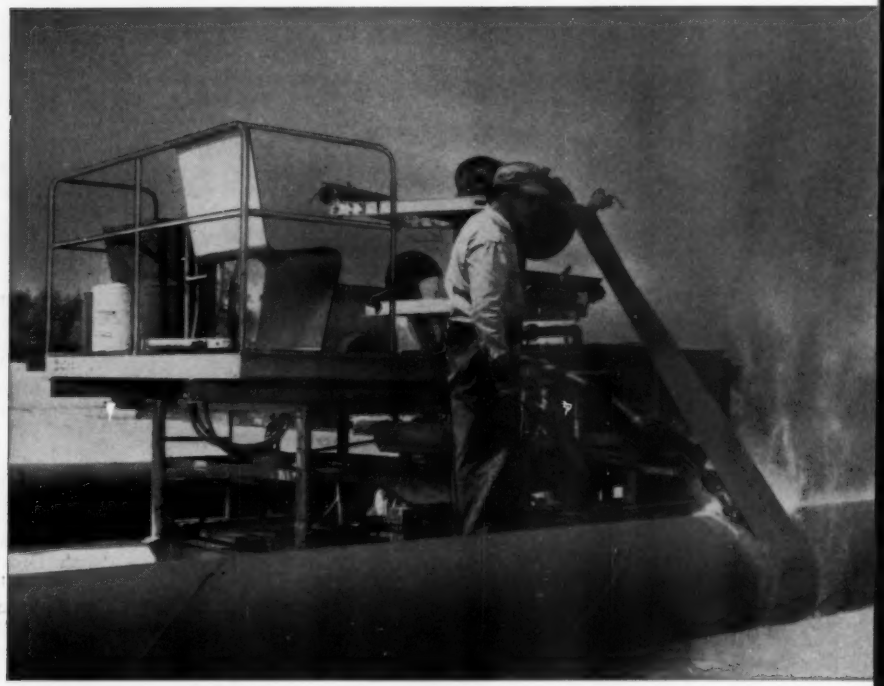
Arguments Against Fluoridation of Water Supplies. H. HORNUNG. Stadtehygiene (Ger.), **6**:219 ('53). With reference to his introduction of fluorine treatment for part of water supply of Kassel, author discusses various arguments which have been raised against this treatment and answers them from his own experience and that of others, including number of American investigators. Among subjects considered are toxicity of fluorine and possibility of accumulation of fluorine in body, existence of antagonism between iodine and fluorine, effect of heating water and of pptn. of hardness on content of fluorine, cost of fluorine treatment, and effect on prevention of caries in children and adults. Fluorine treatment in Kassel has not been carried out long enough to draw definite conclusions but it has been noted that incipient caries in teeth of children receiving treated water did not develop in 2 years, whereas similar spots in children receiving untreated supply developed into cavities.—*WPA*

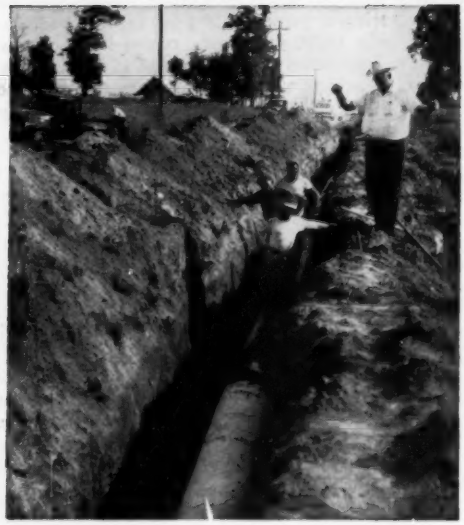
The Fluoridation System at the South District Filtration Plant. J. R. BAYLIS. Pure Water, **8**:86 (May '56). Description of equip. for handling and adding hydrofluosilicic acid to water at South District Filtration Plant, Chicago. Hydrofluosilicic acid is received in 8,000-gal rubber-lined railroad tank cars and siphoned to four 6,300-gal capac. storage tanks below street level. From storage tank acid is moved to feeding tank by means of Olivite rubber-lined centrifugal pump of 30-gpm capac. Feed tank has 18,500-gal capac., rubber-lined, and was constructed on site because of size. Hydrofluosilicic acid is fed into water at 3 locations using a 3-gang Milton-Ray plunger pump.—*PHEA*

A Physician Looks at Fluoridation. J. M. MATHER. Can. J. Public Health, **47**:24 ('56). In paper read at annual meeting of Canadian Public Health Association, 1955, author reviews statistics and published literature on inadequacy of dietary control, oral hygiene and dental treatment to deal with problem of dental disease, and on reduction of incidence of dental caries by consumption of naturally or artificially fluoridated water; particular reference made to surveys made at Brantford, Ont., since fluoridation of water supply was started in 1945. Some arguments in opposition to fluoridation are examined. Emphasis is laid on duty of public health workers in educating public to accept

(Continued on page 68 P&R)

LENOIR, N. C. PLANS FOR THE FUTURE





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(*Continued from page 65 P&R*)

fluoridation of communal water supplies as safe, effective, and cheap means of preventing dental disease.—*WPA*

Fluoridation of Water Supplies. J. R. FORREST. J. Roy. Soc. Health, **76**:244 ('56). Account of experimental fluoridation in the USA. 1.0–1.2 ppm of fluorine has been selected as optimum level and the well-known experimental schemes in Grand Rapids and Newburgh, in USA, and Brantwood, in Canada, adopted this level. In all cases, reduction in D.M.F. teeth in children, whose teeth had calcified during period of fluoridation, was about 60% in fluoridated areas compared with control communities. Effect of high fluorine in water was demonstrated by very thorough investigation in Bartlett, Texas. There were no significant medical differences between Bartlett and Cameron (control town) save that cardiovascular abnormalities were higher in Cameron and there was noticeable fluorosis in Bartlett. In Britain, as in many other parts of world, some 9 in 10 of pop. suffer from caries and by 35 yr. of age 1 in 6 have full upper and lower dentures. In UK, 4 areas will shortly have fluoride added to water to demonstrate effectiveness of this mass-prophylaxis under British conditions. Author concludes "If, instead of having 6 defective teeth at age 12, children have caries rate as low as 2.6, as it is in areas with 1.0 ppm of fluoride, fluoridation would have proved worth while."—*PHEA*

Fluoridation of Domestic Water Supplies—Assessment and Maintenance of Dose to be Applied. J. LONGWELL. Proc. Soc. Water Treatment and Exam. (Br.), **4**:44 ('55). Author gives up-to-date review of subject and relates American experience to British conditions. Results of American work is reported in detail. After discussing different drinking habits of British, especially heavy consumption of tea, it is concluded that daily intake of combined fluorine in Britain is closely similar to that in U.S.A. Results of past decade of experimental fluoridation in America are, accordingly, relevant to British conditions. An outline specification for fluoridation is given.—*PHEA*

Effect of Topical Fluorides on Teeth Matured on Fluoride-bearing Water. D. J. GALAGAN & J. R. VERMILLION. Public Health Repts., **70**:1114 ('55). Data presented here neither confirm nor indicate that topical fluoride applications are effective when used on teeth matured on fluoride-bearing water, since 9% reduction demonstrated may be attributable to chance variation. Further study of greater numbers of children is indicated before conclusions can be drawn.—*CA*

Fluorosis and Dental Caries at Barcellona Pozzo di Gotto (Sicily). O. SPADARO & V. PAGANO. Igiene e sanita pubblica (Sp.), **11**:403 ('55). In 8 spring and well waters near Barcellona Pozzo di Gotto, amts. of 0.430–1.866 mg/l F (method of Villard and Winter) were found. Considerations about incidence of tooth fluorosis and caries are made.—*CA*

LABORATORY METHODS

Automatic Coulometric Titration With Electrolytically Generated Silver Ion. J. J. LINGANE. Anal. Chem., **26**:622 ('54). Method for detg. chloride, bromide, and iodide ions by automatic coulometric titration is described. Titration cell contains Ag anode and P cathode which are connected to source of constant current and Ag indicator electrode connected through Beckmann automatic titrator to reference electrode which is connected by salt bridge to titration cell. Silver ions are produced at constant rate at anode and are removed from soln. by pptn. as Ag halide. As equivalence point is reached, potential, measured by indicator electrode, rises. At potential corresponding to equivalence point, which is established by trial, autotitrator is set to stop titration; time during which current flows is recorded by stop clock. Current is applied in small increments near endpoint. Chlorides in low concns. should be det. in presence of 80% ethanol to reduce sol. of Ag chloride. Titration curve for iodides is distorted because of adsorption of iodide ions by ppt. It is therefore better to titrate to isoelectric point at $pAg = 6.0$ rather than equivalence point at $pAg = 8.0$, and to make correction for slight excess of Ag ions. 2 types of systematic error which may arise are discussed. Accuracy is of order of ± 0.004 mg for chlorides and bromides and ± 0.006 mg for iodides for amts. ranging from 0.2 to 10 mg in 50 ml of soln.—*WPA*

(*Continued on page 72 P&R*)

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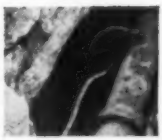

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pipe FOR MODERN WATER WORKS

(*Continued from page 68 P&R*)

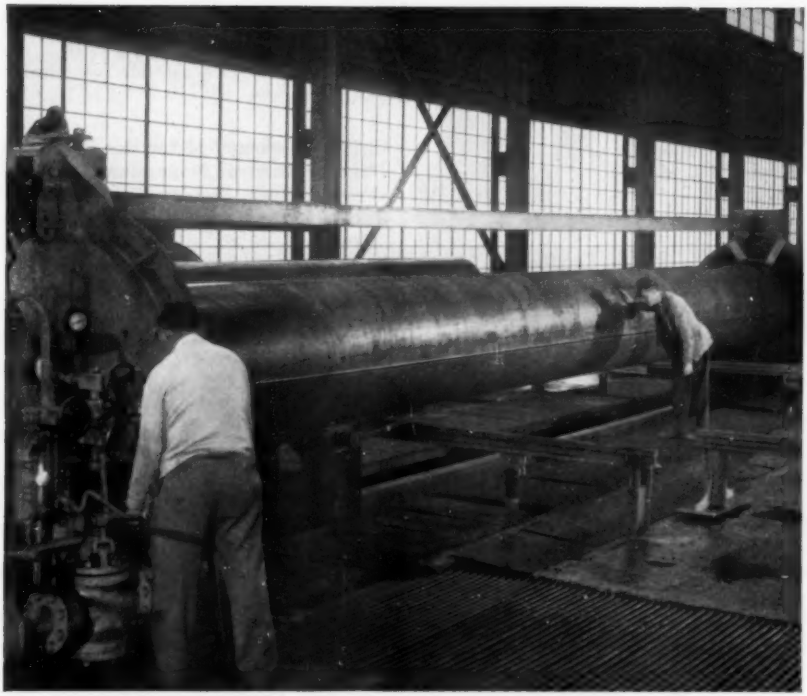
Titration of Iodide With Electrolytically Generated Silver Ion. R. L. KOWALKOWSKI, J. H. KENNEDY & P. S. FARRINGTON. Anal. Chem., 26:626 ('54). Secondary coulometric procedure for titrating iodides with electrolytically generated Ag ions in presence of acetate buffer is described. Generator electrodes were Ag anode and P cathode, which was immersed in shield contg. sulfuric acid. Indicator circuit consisted of Ag anode and P cathode to which small potential difference was applied. Blank runs were made using distd. water and acetate buffer; Ag ions were generated for short periods, and indicator current was plotted against time and best straight line drawn. Intercept on time axis was taken as blank correction. During titration of sample, indicator current fell sharply near equivalence point; microammeter readings were then taken after every sec of current generation until indicator current increased linearly with time of generation. Linear current values were extrapolated back to 0 current, and corresponding generation time was corrected by blank time to find net titration time and hence amt. of Ag ions produced. Accuracy was ±0.1% for 0.778–22.6 mg iodide and ±0.6% for 0.28 mg iodide. Alternative procedure in which titration is carried out in strongly acid soln. using 2 Ag indicator electrodes, is briefly mentioned.—*WPA*

Nephelometric Determination of Sulphates in Water. VIRE. Tech. Eau (Belgium), 8:85:17 ('54). Nephelometric method is described for detg. sulfates as colloidal soln. of barium sulfate stabilized with gelatin. Relation between concn. of sulfate and optical density of soln. is nearly linear at pH 3. Reagent soln. is prepared by mixing solns. of gelatin and Ba chloride, clarifying soln. by adding emulsified white of egg, heating to boiling, and filtering, adding soln. of mercuric chloride to filtrate, and adjusting pH value to 3 with hydrochloric acid. Soln. is stable for several months. Soln. to be analyzed is acidified to pH 3, treated with reagent soln. allowed to stand for 10 min, shaken, and light absorption measured in spectrophotometer at 530 mμ. Calibration curve is plotted using std. solns. of Na sulfate. For concns. of sulfate between 20 mg/l and 160 mg/l, error is ±3%. For more concd. solns., sample must be dild.—*WPA*

Estimating the Tritium Content of Tritiated Water. W. A. JENKINS. Anal. Chem., 25:1477 ('53). Method has been developed for making rapid approximate ests. of amt. of tritium in tritiated water. Known weights of NH_4Cl were tritiated by dissolving them in known vols. of tritiated water, allowing soln. to stand for 10 min, and distg. off water. NH_4Cl was dried and its activity measured. On plotting activity of water against that of NH_4Cl, straight line was obtained, indicating that ratio of activities is constant. Second series of expts. gave 5% higher value for this ratio. It was found that activity of tritiated NH_4Cl was dependent on initial concn. of NH_4Cl when this was greater than 2 g/10 ml tritiated water. 2 further series of expts. were therefore made, using lower concn. of NH_4Cl (1.5 g/10 ml) and values for ratios of activities agreed fairly closely. Mean value of 3.58 for ratio of activity of solid compd. to activity of tritiated water used to render solid active could therefore be used to det. activity of unknown soln. and it is estd. would give results with max. error of 15%. —*WPA*

Assay of Certain Organic Materials by Dichromate Oxidation. N. F. SCHULZ. Anal. Chem., 25:1762 ('53). Procedure described for detn. of org. substances dissolved or suspended in water in concns. of less than 250 ppm. Method involves oxidation with K dichromate and has been applied to detn. of starch, laurylamine acetate, and Na oleate. Sample is heated in autoclave with soln. of K dichromate in sulfuric acid for ½ hr at 120°C or 2 hr at 100°C. Excess dichromate is detd. either colorimetrically or by titrating with ferrous ammonium sulfate in presence of phosphoric acid to 4 ml beyond endpoint and backtitrating with permanganate soln. Oxidation is not complete, but amt. of dichromate used is proportional to amt. of org. material initially present, which is, therefore, calcd. on basis of titrations of known solns. Rate and extent of oxidation are functions of concns. of dichromate and acid and of temp. and time of reaction. By controlling reaction conditions, such as acidity, different substances may be detd. in same soln. Accuracy of method was within range of accuracy of volumetric measurements and was ±0.02 mg starch or ±0.01 mg of laurylamine acetate. In strongly acid reaction mixtures,

(*Continued on page 74 P&R*)



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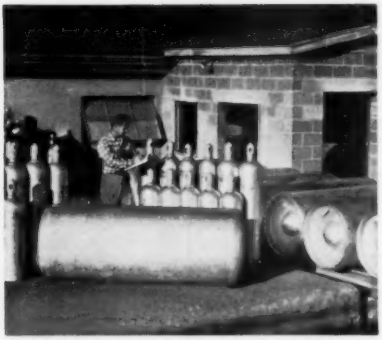

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(*Continued from page 72 P&R*)

more than 0.02 meq chloride ion interfered. —*WPA*

Simple Micromethod for the Photometric Determination of Magnesium With Eriochrome Black T. W. DIRSCHERL & H. BREUER. Mikrochemie Ver. Mikrochim. Acta (Germany), **40**:322 ('53). Micromethod for detg. Mg colorimetrically as Eriochrome black T complex is described. Excess of dye used to ensure stability of complex. Samples are compared colorimetrically with solns. of pure dye, and preferably at 2 wavelengths, 533 mμ and 655 mμ, in order to facilitate detection of interference. Ca interferes at concns. greater than twice that of Mg and should be removed by pptn. as oxalate. Zn, Cu, and ferric Fe interfere but may be masked with cyanide; ferrous Fe should be oxidized to ferric Fe. Al in equimolecular or greater concns. and Na and K in concns. greater than $\frac{1}{100}M/l$ interfere. Mg can be detd. at concns. as low as $5 \times 10^{-4}M/l$. Mean error is about ±5%.—*WPA*

Rapid Microcolorimetric Determination of Dissolved Oxygen. W. F. LOOMIS. Anal. Chem., **26**:402 ('54). Rapid microcolorimetric method for detg. DO in water is described. It depends on partial oxidation of reduced indigo carmine to red semiquinone and detn. of color intensity. 1% soln. of indigo carmine, reduced with glucose and contg. potassium carbonate and slight excess of glucose, is kept under positive pressure of nitrogen. 1-ml tuberculin syringe is filled with reagent to about 0.8-ml mark by inserting hypodermic needle through rubber stopper of reagent bottle. Needle is removed and syringe is fixed in absorption cell of spectrophotometer, and blank absorbance is detd. Plunger is advanced to 0.50-ml mark and sample of water to be tested is drawn into syringe to 1.0-ml mark and its absorbance detd. immediately. At wavelength of 580 mμ, relation between % saturation with air and absorbance is almost linear and calibration curve can be constructed using reagent alone and with 100% saturated water. Interference is caused by compds. capable of oxidizing or reducing indigo carmine. Accuracy is within ±0.2 mg/l oxygen over range extending from fully anaerobic to aerobic conditions. Anal. can be completed in about 1 min.—*WPA*

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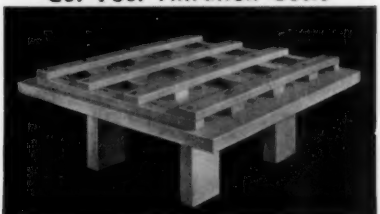

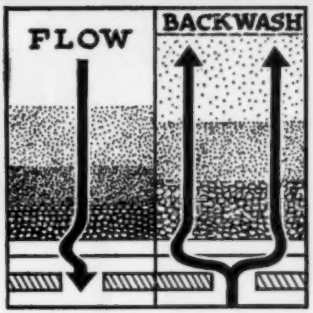

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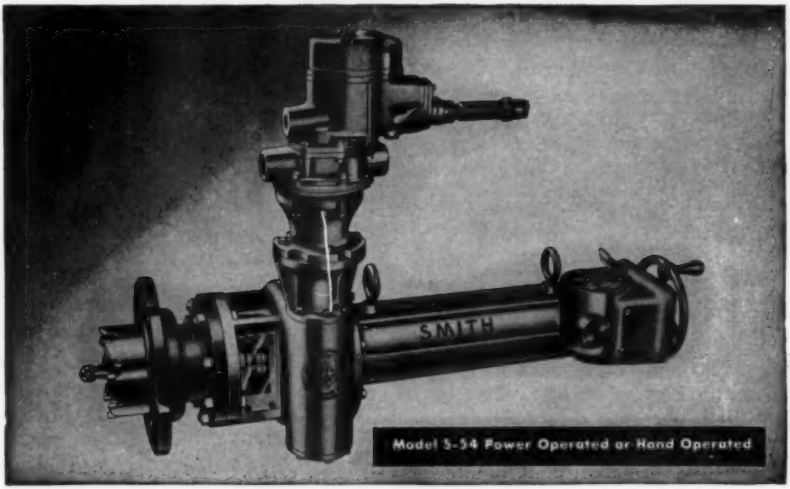

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(Continued from page 48 P&R)

That water is the cat's meow has at last been conclusively demonstrated. The proving ground involved was a new home in Glendora, Calif., into which the Vincent Carta family had moved early in January and out of which they were almost driven before the end of the same month by 24 days of continual caterwauling—the maddening meowing of a cat inside their walls. No sooner had word of the in-a-wall mousetrapper leaked out than all the world beat a path to the Carta's door —by mail, by wire, and by phone, if not in person—with suggestions on how to free the fretting feline. Acting on such of the advice as made any sense at all, the Cartas and the builder, whose payment remained in escrow until the home's pusslessness had been established, put in 3 weeks of catcalling, using milk, catnip, fish, probes, dogs, even a tom cat, and, finally, a fluoroscope to find the kitty. When all these methods failed, when the telephone had long since been disconnected to allow the Cartas more than a catnap, and when the curiosity seekers had all but driven the family out, hammers and chisels were brought in and a direct approach was made—through the newly decorated walls. It was when she surveyed the resulting mess—the still catless mess—that Mrs. Carta was ready to give up the ghost, and the house with it.

That, of course, was the dramatic moment when AWWA member Ole Hammer and a sound engineer made their entrance and, in a matter of minutes, using an electronic sound device, traced the meowing to the curbside meter, where a faulty disc had "squeaked" at every turn. Thus, whenever water was drawn inside the house, the squeaking started and, amplified by the plumbing, played pussy in the wall. What with two children already and a third on the way, the Cartas used plenty of water—and often, too—thereby keeping kitty on the run.

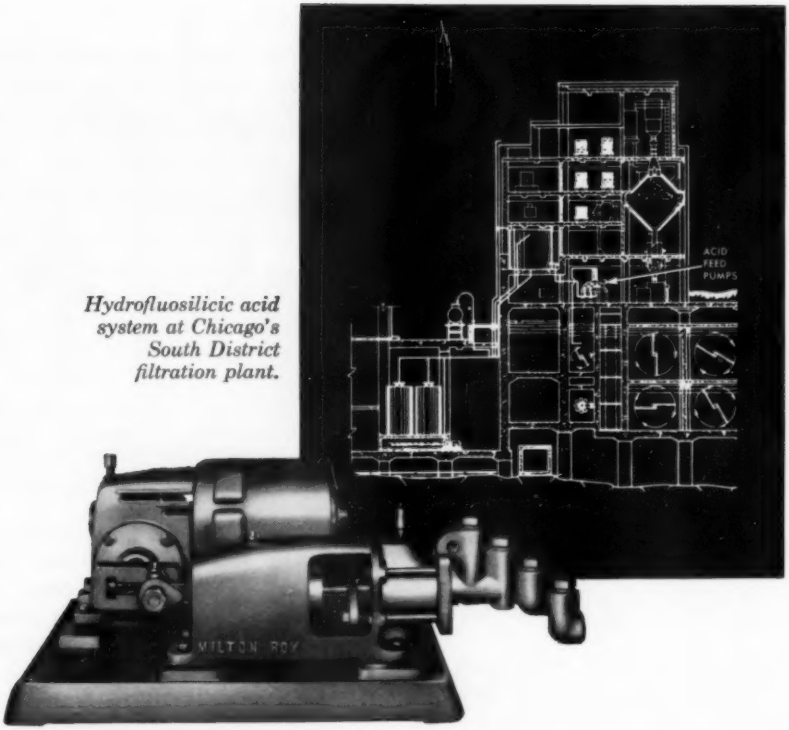
Now with the defective meter replaced, the telephone reconnected, the holes in the walls patched at the expense of the builder, and the frequency with which they use water fully appreciated, the Cartas are living again. And who would be surprised if, in recognition of their hard-won freedom from persecution, they named their next-born "Magna." That is, unless, with the cat away. . . .

Gordon Research Conferences, established to stimulate research in universities, foundations, and industrial laboratories, will be held this year from Jun. 10 through Aug. 30 at three New Hampshire schools. The meetings consist of lectures and discussion groups aimed at fostering free and informal exchange of ideas among persons actively interested in the subjects covered. Of particular interest to the water works field is the Conference on Ion Exchange, to be held Aug. 5–9 (see Coming Meetings, p. 8 P&R).

Joseph A. Heiman has been named purchasing agent for Rockwell Mfg. Co. Instrument Div., Tulsa, Okla. Succeeding him as senior buyer in Rockwell's general purchasing department at Pittsburgh is James N. Huber.

Henry F. Dever, president of Minneapolis-Honeywell's Brown Instruments Div., Philadelphia, has been given corporate responsibility for directing the parent company's activities in the industrial-controls field. He will counsel and coordinate the engineering and manufacturing operations of seven Minneapolis-Honeywell divisions now active in this field.

(Continued on page 80 P&R)



Hydrofluosilicic acid system at Chicago's South District filtration plant.

Controlled Volume Pumps feed fluorides to Chicago's water

Every day, 1400 gallons of 23% hydrofluosilicic acid are added to 340,000,000 gallons of water at Chicago's South District filtration plant. The exacting job of feeding this highly corrosive acid in correct proportions is entrusted to Milton Roy Controlled Volume Pumps.

The Controlled Volume Pump system consists of three direct-displacement pumps, powered by one electric motor through variable speed transmission. One pump serves each of three acid mixing basins. Each pump has a maximum capacity of 43 gallons per hour.

In any water treating job, Milton Roy Controlled Volume Pumps provide the logical, economical answer to accurate flow control and chemical metering. Write for technical information. Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

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(Continued from page 78 P&R)

'Wolf' has been cried twice within less than a month now—a sort of weir-wolf, that is—and if the cry spreads any further, water utilities are going to find themselves in trouble with their customers when they have to make repairs to their distribution systems. First wolfcall was at Norman, Okla., in mid-January, when someone who identified himself as a "water department employee" called the 16 sorority and 24 fraternity houses on the University of Oklahoma campus and warned them that their water would be shut off the following day. And 2 weeks later at Great Neck, N.Y., someone cried out louder, giving local housewives this telephone message:

> This is a recording . . . your water will be turned off in 15 minutes . . . fill up your bathtub, your sink, and all receptacles that hold water.

Appreciating the importance of water, both Norman's sisters and brothers and Great Neck's wives built up beautiful peak hours in the process of getting set for the ordeal. And when the ordeal didn't come on schedule, it was the water department at Norman and the Citizens Water Supply Co. at Great Neck that underwent one. At the university some of those rugged football stars and at Great Neck the Nassau County Police are on the prowl for the wolfcallers involved. And to deter any incipient wolves, we're putting our money on the Sooners. How can we lose?

Deep purple highballs, black potatoes, charcoal gray vegetables, and green coffee are just part of the colorful menu that is said to be characteristic of many parts of Alaska. Cause of this acute rainbowism is apparently the excess of iron, manganese, and calcium that makes the ground waters and, often, even the surface waters of the Alaskan interior and western tundra almost thick. Its effect, aside from making the inhabitants drink their liquor straight, has been to start the University of Alaska researching methods by which the water can be made potable on a home treatment basis as well as by the military, which is constructing bases in various areas that depend on the extremely hard water for all uses. That's education, of course—and the vanishing frontier. Next thing you know, our rugged northern friends will be so soft they'll see purple only after the highballs.

Thomas J. Skinker has retired as St. Louis water commissioner after more than 15 years in the post. As commissioner, he was in direct control of all phases of the city's water supply and, in the words of the director of public utilities, Conway B. Briscoe, "rendered invaluable service to our community. . . . A great deal of credit must be given him for the high standing which our Water Div. has attained."

Raymond E. Hebert, president of Filtration Equipment Corp., Rochester, N.Y., has been appointed director of the Water & Sewerage Industry & Utilities Div. of the Business & Defense Services Administration, US Dept. of Commerce. Like his predecessor in the office—Richard V. Ford, vice-president, Ford Meter Box Co.—Mr. Hebert is on loan from his company and will serve, without compensation, for a period of 6 months.

William J. Speir has been named general manager of Waterworks Equipment Co., Salt Lake City, Utah.

(Continued on page 84 P&R)

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6 to 10 Times More Bearing Contact Area

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Beamed Waterway Gate Valves

No wonder they live to a ripe old age. Even after decades of rugged service, you get smooth operation, tight seats, and practically no leakage. There's 6 to 10 times more bearing contact area in the partly opened position. That's 6 to 10 times more of what you want with a Chapman than with any other double disc parallel seat or square bottom gate valve.

With long wearing bronze bearing surfaces on beams and downstream discs, this Chapman Valve is just the valve you need for filtration plants, wash water valve service or other places where limited throttling is in order. Available in all standard sizes with any desired method of operation.

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Settling and subsequent water treatment benefit from clean liquid alum.

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ore efficient waterworks!

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"The economic facts were so well detailed that our Board of Trustees readily agreed we couldn't afford to pass up the annual savings. They approved the appropriation.

"The installation has been in use for a year. It's obvious we'll pay off within the estimated period. After that, there will be cheaper water treatment for Westchester.

"But there are benefits that don't show up on the budget. *Liquid* Alum is easier to handle in unloading, storage and use, permitting a much cleaner operation as well as reduced labor and supervision. We now have much greater operating flexibility."

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(*Continued from page 80 P&R*)

Carleton E. Davis, former president of AWWA and vice-president of Philadelphia Suburban Water Co., Bryn Mawr, Pa., died Jan. 29, 1957, at his home in Merion, Pa. He was 87. Born in Brookline, Mass., he was graduated from Massachusetts Institute of Technology in 1893. From 1900 to 1903 he was resident engineer for the Newark, N.J., water supply. The next 2 years, as engineer for the Isthmanian Canal Commission, he constructed water and sewage works in the Panama Canal Zone. In 1906 he became department engineer for the New York City Board of Water Supply, leaving to take the post of chief of the Philadelphia Bureau of Water in 1913. Ten years later he accepted the position of manager of Indianapolis Water Co., but returned to Philadelphia in 1925 to manage the Philadelphia Suburban Water Co. He afterwards became vice-president and director and, at the time of his death, was serving the company as a consultant.

An Honorary Member of AWWA since 1939 (he joined in 1912), Mr. Davis was elected vice-president in 1919 and president in 1920. He received the Fuller Award in 1951. Other organizations to which he belonged include ASCE and NEWWA (past president).

(*Continued on page 86 P&R*)

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Butterfly
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Built to AWWA Standard Specifications C504-55T

- **Compact—Lighter Weight**
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- **Lowest Installed Cost**
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- **Drop-Tight Shutoff**
- **Minimum Restriction to Flow**
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Write for Bulletin 574 on AWWA Valves

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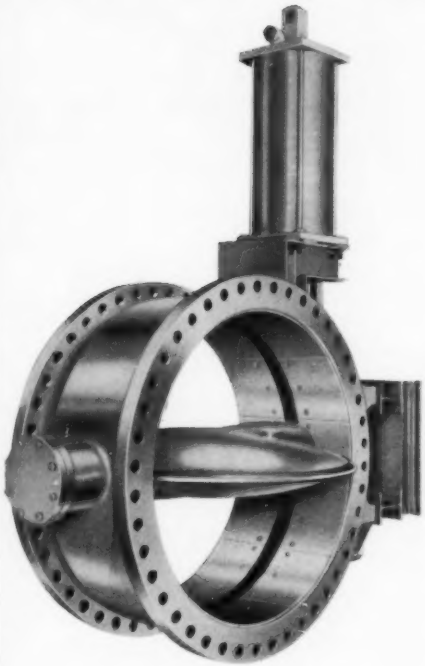

W. S. Rockwell Butterfly Valves offer advanced design and rugged construction. Made in all standard sizes of cast iron, cast steel, stainless steel, bronze or other alloys; natural or synthetic gum rubber seat with clamping segments, or spool type rubber liner extending over flange faces. Operators — manual: AWWA nut, handwheel, chain wheel or other types; automatic: electric motor or cylinder.

W. S. ROCKWELL COMPANY
2607 Eliot Street — Fairfield, Connecticut

(Continued from page 84 P&R)

Charles G. Richardson, retired vice-president of Builders-Providence, Inc., division of B-I-F Industries, Inc., died Feb. 3, 1957, after an illness of several months. A native of Morrisville, N.Y., and a graduate of Brown University in 1900 as a mechanical engineer, he spent 3 years in drafting and design work at Brown & Sharpe Mfg. Co. before joining Builders Iron Foundry as assistant chief engineer. In 1935 he became a sales engineer and later manager of sales. In 1944 he was made vice-president of Builders-Providence. He held several patents in the field of meters and controls and was the author of more than 50 technical and historical articles.

Active in many technical societies, Mr. Richardson was a Life Member of AWWA (joined in 1920), ASCE, NEWWA, and the Providence Engineering Society. He was also a member of the New England Sewage & Industrial Wastes Assn. and for a number of years served as a member of the board of governors of the Water & Sewage Works Manufacturers Assn.

Charles-Edward Amory Winslow, professor emeritus of public health, Yale University School of Medicine, died Jan. 8, 1957, at the age of 80. Born in Boston in 1877, he was a graduate of Massachusetts Institute of Technology, where he received his M.S. in 1899. His first interest was bacteriology, but his distinguished career covered many phases of public health. He taught at M.I.T., College of the City of New York, University of Chicago, and Yale University (where he was the first chairman of the Dept. of Public Health). He was curator of public health at New York's Museum of Natural History, director of the Div. of Public Health Education of the New York State Dept. of Health, and a member of numerous national and international public health organizations. He served a term as president of APHA and was editor of its journal. Author of more than 600 articles and books, he was concerned in the development of *Standard Methods.* His many honors include the Lasker Award (APHA), the Sedgwick Memorial Medal (APHA), the Anderson Medal (American Society of Heating & Ventilating Engineers), and the Bernard Medal (World Health Organization).

Public construction accounted for 33 per cent of all contract awards in 1956, compared with 31 per cent in 1955, according to a review by F. W. Dodge Corp., covering 37 eastern states. In dollar terms, this represented a 15 per cent increase, contrasted with a 4 per cent drop in residential building and a 1 per cent gain in the commercial and manufacturing category. Moreover, public construction held up better than private over the year; in the last quarter of 1956, public ownership contracts were still running ahead of 1955, while private contracts were far below 1955 levels.

Gilbert V. Levin, formerly public health engineer and civil defense coordinator for the Dist. of Columbia Dept. of Public Health, has joined the consultant firm of Resources Research, Inc., Washington, D.C.

Hapgood Kipp has taken the post of Philadelphia district manager for Simplex Valve & Meter Co., Lancaster, Pa. Mr. Kipp was formerly with American Water Softener Co. and Belco Corp.

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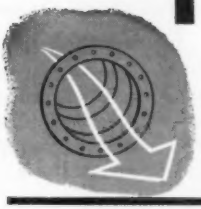

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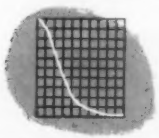

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AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED • TORONTO

The Reading Meter

Plastics for Corrosion-resistant Applications. *Raymond B. Seymour & Robert H. Steiner. Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y. (1955) 423 pp.; $7.50*

This book supplies background information for selecting the proper plastic for construction in corrosive atmospheres. It describes the physicochemical properties and molecular structure of plastic materials, and goes on to discuss their applications, including protective coatings and linings, mortar cements, pipe, valves, fittings, and flooring (pipe for water supply is briefly covered).

A Study of Plastic Pipe for Potable Water Supplies. *Directed by Walter D. Tiedeman, assisted by Nicholas A. Milone. National Sanitation Foundation, School of Public Health, Univ. of Michigan, Ann Arbor, Mich. (released in 1956) 90 pp.; paperbound; $1*

This study, conducted over a 3-year period, was designed to show whether any substances that might be deleterious to health would be extracted from plastic pipe by an aggressive potable water and whether the appearance, taste, or odor might be affected. Test data and conclusions are given. A synopsis of this report was published in the August 1956 JOURNAL (pp. 1019–23).

Plastic Pipe at Work. *Society of the Plastics Industry, 250 Park Ave., New York 17, N.Y. (2nd ed., 1957) 39 pp.; paperbound; free*

Prepared by the Thermoplastic Pipe Div. of SPI, this brochure deals with the use of plastic pipe in potable-water applications such as jet wells and well-to-building piping. The attitude of certain state health departments is discussed, and there is a section on the use of plastic pipe in Europe. Numerous photographs showing installation procedures are included.

ACI Manual of Concrete Inspection. *American Concrete Institute, 18263 W. McNichols Rd., Detroit 19, Mich. (3rd ed., 1955) 232 pp.; $2.50*

The manual describes inspection methods generally accepted as good practice in the concrete construction industry. It is intended as a supplement to job specifications and as a guide in matters not covered by them. New material in the third edition covers such subjects as air entrainment, ready-mixed concrete, and the latest special concrete construction methods. Chief feature of the new edition is a general expansion of explanatory matter so as to be of greater use to the inspector.

Composition and Properties of Concrete. *George E. Troxell & Harmer E. Davis. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y. (1956) 434 pp.; $7.75*

This book deals with the characteristics and proportioning of cements, aggregates, admixtures, and water used in concrete mixes, as well as with the batching, mixing, and placing of concrete to produce an economical finished product of suitable and predictable quality. There is also a section containing instructions for laboratory tests selected to illustrate important facts and principles connected with the use of cement, aggregate, and concrete.

(Continued on page 90 P&R)

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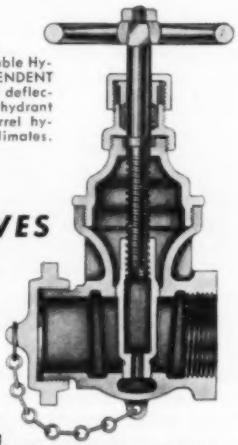

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The Reading Meter

(Continued from page 88 P&R)

Accident Prevention Manual for Industrial Operations. *National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill. (3rd ed., 1955) 1,341 pp.; $13.50*

Larger by seventeen sections and over 500 pages than the 1951 edition, this manual is devoted chiefly to safety in manufacturing industries, but many sections are applicable to other operations. Among the new material are chapters on safety program organization, employee education, sanitation and industrial hygiene, motorized equipment, and safety engineering data. A number of other sections—including accident records, protective equipment, and chemical hazards—have been substantially revised and expanded.

Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions. *National Board of Fire Underwriters, 85 John St., New York 38, N.Y. (6th ed., 1956) 106 pp.; free to officials concerned*

Some modifications have been made in the new edition (the first since 1942) to recognize present good practice and modern developments, but these will not materially affect previous gradings of municipalities that have progressed with the times. Changes in wording and arrangement have also been made to clarify the meaning of certain sections and to make the schedule more convenient to use.

Handbook of Material Trade Names—Supplement I. *O. T. Zimmerman & Irvin Lavine. Industrial Research Service, Dover, N.H. (1956) 383 pp.; $12.50*

This supplement, like the parent 1953 volume (see September 1953 Reading Meter, p. 50 P&R), contains an alphabetical listing of trade-named products ranging from "A-1 Chemstone" to "Zytel Nylon Resin." Each product is briefly described and the name of the manufacturer is given. There is a separate directory of manufacturers and their products, as well as a subject classification section showing products of similar type. It is, of course, impossible to judge how thorough the supplement is, but some indication may be gathered from the fact that the two trade names mentioned by the JOURNAL reviewer as missing in the 1953 volume are included in the supplement.

Handbook of Chemistry. *Norbert A. Lange & Gordon M. Forker, ed. Handbook Publishers, Inc., Sandusky, Ohio (9th ed., 1956) 1985 pp.; $8.50*

The ninth edition of this well known and ever useful handbook contains a score of new tables, covering: properties of plastics; relative humidities and aqueous tensions of sulfuric acid, sodium hydroxide, and calcium chloride solutions; polarography; hydrometer scale comparisons; and other subjects. Formula weights of inorganic compounds and gravimetric and volumetric factors have been computed to conform to the latest international atomic weight values. Numerous other revisions and changes have been made.

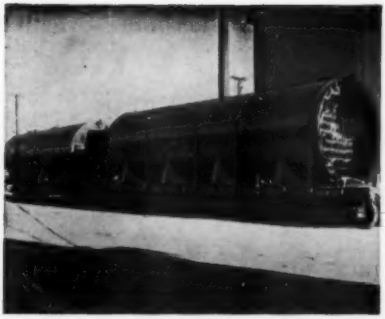
Bibliography on Fluoridation of Public Water Supplies. *Municipal Reference Library, Detroit Public Library, 1006 City-County Bldg., Detroit 26, Mich. (1956) 8 pp.; mimeographed, paperbound; free*

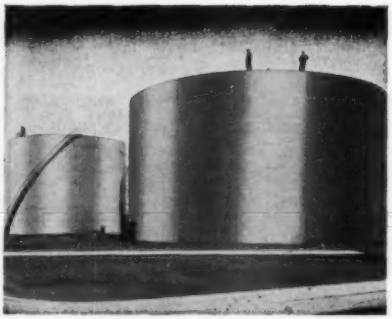
This briefly annotated bibliography on fluoridation lists mainly articles appearing in American and Canadian periodicals.

Standards of the Hydraulic Institute. *Hydraulic Institute, 122 E. 42nd St., New York 17, N.Y. (10th ed., 1955) 234 pp.; looseleaf; $4.75*

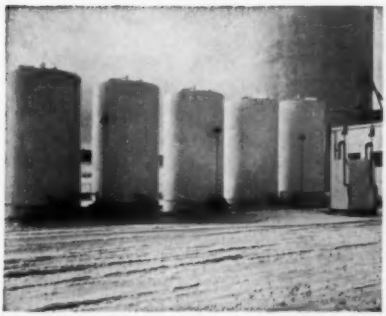
The tenth edition of these standards on centrifugal, rotary, and reciprocating pumps constitutes a complete revision and rearrangement of the format and engineering data of earlier editions. The

(Continued on page 92 P&R)





Here's the answer



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The Reading Meter

(Continued from page 90 P&R)

standards cover classification, nomenclature, application, rating, testing, installation, operation, and maintenance. There is also a data section on friction losses, construction materials, and other relevant matters. The looseleaf binding will enable future revision sheets to be inserted in their proper place. A revision notification service is offered by the institute.

American Standard Graphical Symbols for Plumbing—ASA Y32.4–1955. *American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N.Y. (1955) 8 pp.; paperbound; $1*

This standard replaces pages 4–9 of American Standard Graphical Symbols for Use on Drawings and Mechanical Engineering—ASA Z32.2.2–1949. The 28 symbols included consist, for the most part, of highly simplified shapes combined with initial-letter abbreviations.

American Standard Letter Symbols for Chemical Engineering—ASA Y10.12–1955. *American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N.Y. (1956) 16 pp.; paperbound; $1*

This standard, a revision of ASA Z10.12–1946, contains letter symbols for concepts, properties, concentrations, and dimensionless numbers in chemical engineering.

American Standard Minimum Requirements for Sanitation in Places of Employment—ASA Z4.1–1955. *American Standards Assn., 70 E. 45th St., New York 17, N.Y. (1955) 12 pp.; paperbound; $0.50*

A revision of ASA Z4.1–1935, this standard covers drinking water, washing and toilet facilities, and restrooms in places of employment.

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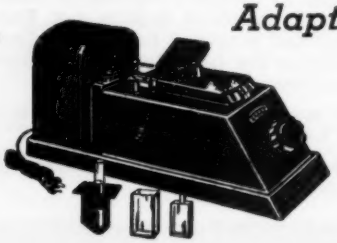
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis

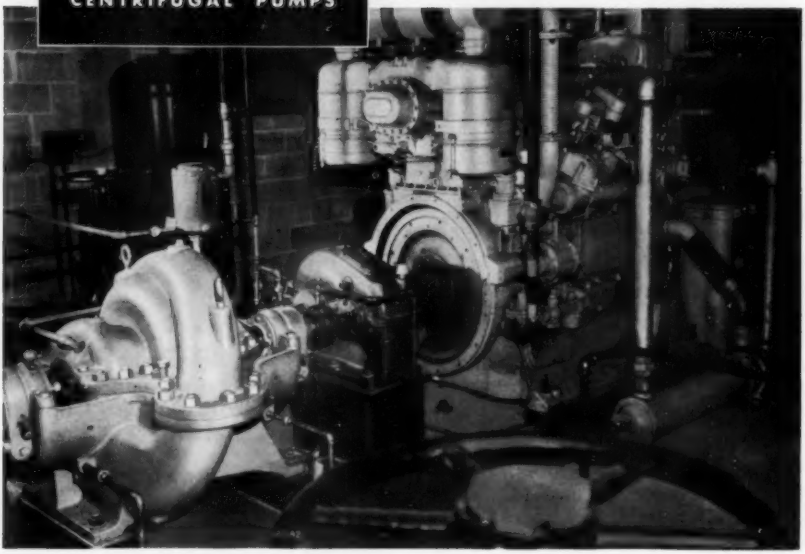


Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.

DE LAVAL
TWO-STAGE CENTRIFUGAL PUMPS

boost pressure at peak loads in Port Washington, New York



This De Laval two-stage horizontal split-case pump is one of a pair used to boost pressure during peak hours in the Port Washington, New York water works. Taking water from a large underground storage tank, these De Laval units maintain pressure throughout the system. The dependable centrifugal pumps are powered by Caterpillar diesels with speed increasers; they deliver 1500 gpm at 400 feet tdh with 15 feet lift requiring 185 bhp.

De Laval 2IS-2KS pumps are designed with • back-to-back impellers for balanced hydraulic thrust • easily replaceable threaded impeller wearing rings • long-life labyrinth case rings • ring-oiled ball bearings — plus ten other important design features. They are available in sizes from 2 inch to 8 inch discharge, for capacities to 3000 gpm and heads to 750 feet. *Write for Bulletin 1501 giving complete data.*

Consulting Engineer:
Angus D. Henderson
Westbury,
Long Island, N. Y.

Contractor:
D. Fortunato, Inc.
Floral Park,
Long Island, N. Y.

DE LAVAL *Centrifugal Pumps*

DE LAVAL STEAM TURBINE COMPANY

822 Nottingham Way, Trenton 2, New Jersey

DL 357A

Service Lines

Swimming pool recirculation and purification system components are described in a 12-page illustrated brochure, Bul. WC-109A, available from Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y.

The Solvay chlorine detector, Series A-689, which monitors a continuous controlled sample of air and warns when chlorine concentrations exceed 3 ppm, is covered in a 4-page bulletin issued by Wallace & Tiernan Inc., 25 Main St., Belleville, N.J.

Valves featuring ease of opening and closing are illustrated in an 8-page bulletin, No. G-4, obtainable from Golden-Anderson Valve Specialty Co., 1221 Ridge Ave., Pittsburgh 33, Pa.

Collector mechanisms for rectangular settling basins are the subject of an illustrated 20-page bulletin, containing design data and specifications, which can be had from Walker Process Equipment Inc., Aurora, Ill.

Quick-opening air valves, Type CCAV, incorporating a controlled closing device said to protect pipelines against the damaging effects of surge and water hammer, are described in Bul. 200 (8 pages), available from Simplex Valve & Meter Co., 7 E. Orange St., Lancaster, Pa.

Polyethylene cable (Type CP) for cathodic protection in water mains, pumping stations, and supply tanks, is described in a 4-page brochure (No. DM-5450) available from Anaconda Wire & Cable Co., 25 Broadway, New York, N.Y.

Centrifugal fire pumps, both single and multistage, are discussed in a 36-page bulletin, No. B-1500, issued by Peerless Pump. The bulletin, which includes six pages of fire pump selection charts and a set of typical installation specifications, is available from Peerless Pump Div., Food Machinery & Chemical Corp., 301 West Ave. 26, Los Angeles 31, Calif.

Continuous mixing without a mixing tank, using the "American Homomix," is discussed in a 10-page addendum to Technical Supplement HM, issued by American Well Works, Aurora, Ill. Copies of Addendum No. 1 can be obtained from the company.

Cast-iron pipe and fittings, as well as fire hydrants, gate valves, and hydraulic machinery, are described (with design data and specifications) in an 80-page catalog issued by R. D. Wood Co., Public Ledger Bldg., Independence Square, Philadelphia 5, Pa.

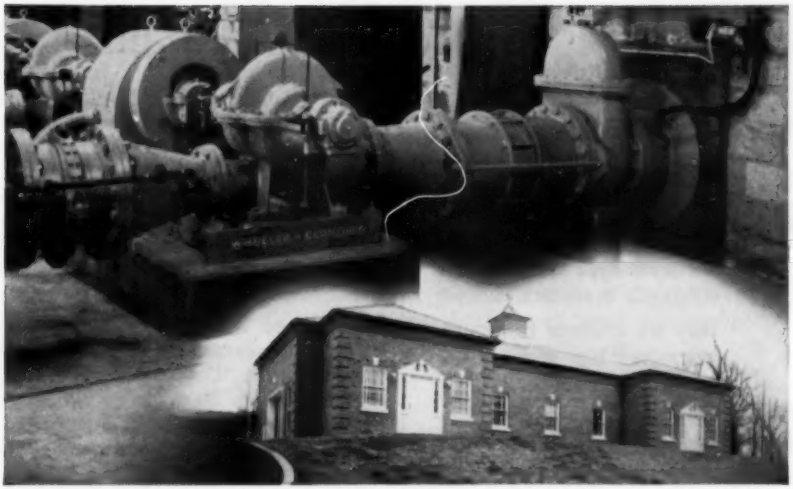
Vertical turbine pumps, water and oil lubricated, are described in Bul. WO-53, published by Layne & Bowler, Inc., Memphis 8, Tenn.

Continuous volumetric feeding of liquids and slurries is discussed in a 4-page brochure, Bul. 65-H12B, on the "Rotodip" Model 65 feeder, a product of Omega Machine Co. (division of B-I-F Industries), 345 Harris Ave., Providence 1, R.I.

Protective coatings made of polyethylene plastic tape are described, with application data, in a 24-page illustrated brochure available from Polyken Sales Div., Dept. IC, Kendall Co., 222 Adams St., Chicago 6, Ill.

A remote control system, in the form of a "plug-in" package, for two-position discrete operation of starters, pumps, and valves, is described in a 4-page brochure issued by Sparton Control Systems Div., Sparks-Withington Co., Jackson, Mich.

(Continued on page 96 P&R)



Note special architectural effort to keep this building in harmony with its residential surroundings.

Hill Road Reservoir of Washington Suburban Sanitary Commission Served by WHEELER-ECONOMY PUMPS

One of the world's largest all-steel reservoirs is the new Hill Road Station built for the Washington Suburban Sanitary Commission in Prince George's County, Md. It has a capacity of ten million gallons. Three Wheeler-Economy Horizontal Double Suction Pumps draw water out of the reservoir and lift it into the supply system. Two of the pumps are 10″ x 8″, with a capacity of 3500 gpm each at a head of 235′, 1750 rpm. The third pump is 8″ x 6″, 2000 gpm capacity at 200′ head, 1750 rpm.

Wheeler-Economy Double Suction Pumps are custom built to meet your specific conditions for most dependable water works service. Case is horizontally split so top half may be lifted for access to rotating parts without disturbing piping or driver connections. Parts are standardized and accurately machined for quick replacement when necessary. Simplicity of design, quality of workmanship and materials give these pumps their reputation for long lived dependability, sustained high efficiency with low maintenance. Many have been pumping for 25 years and more without replacement of major parts. That's why so many Wheeler-Economy Pumps are going into modern water works systems. Have you talked to a Wheeler representative? There's one near you.

Write for Catalog A-156.

WE-702

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C. H. Wheeler Manufacturing Co. • Economy Pump Division
19th and Lehigh, Philadelphia 32, Pa.

ARE YOU RESPONSIBLE FOR MEASUREMENT OF FLUID FLOW?

Gentile* FLOW TUBES

are impact-type head meters or differential producers.

They are designed to give you guaranteed high accuracy with lowest head loss.

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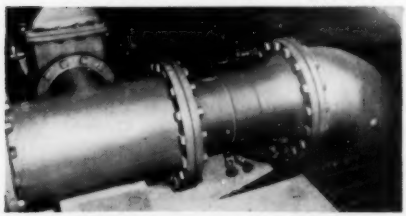
You also get:

LOW FIRST COST—Gentile Flow Tubes are economical to purchase.

LOW OPERATING COST—Gentile Flow Tubes require minimum maintenance. Where purging or back-flushing is a normal routine, the Gentile Flow Tube can be arranged for constant or intermittent purging without removing from the line.

LOW INSTALLATION COST—Gentile Flow Tubes can be installed with no straight run upstream or downstream, except where near valves or regulators.



Actual installation of a 16" Flow Tube for REVERSE FLOW. Note fittings (elbow and tee) are bolted directly to flanges of Flow Tube.

Gentile Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments.

GENTILE Flow Tubes are manufactured exclusively by Foster Engineering Company

Write for further information or specific recommendations.

FOSTER ENGINEERING COMPANY

835 LEHIGH AVENUE UNION, N. J.

AUTOMATIC VALVES • CONTROL VALVES
SAFETY VALVES • FLOW TUBES

Service Lines

(*Continued from page 94 P&R*)

Waterstop test results are the subject of a report published by Electrovert Inc., makers of "Durajoint" and "Duraseal" stops. Copies of Technical Report No. 1 are available from W. R. Meadows, Inc., 7 Kimball St., Elgin, Ill., or from Tecon Products Inc., 304 Alaskan Way, Seattle, Wash.

Combined flocculation and clarification in a single tank is the subject of Bul. 6801-R, on the "Dorrco Clariflocculator," obtainable from Dorr-Oliver Inc., Barry Place, Stamford, Conn. Another 12-page bulletin, No. 6001-R, covers the design, operation, and maintenance cost of the "Dorrco Monorake," for cleaning rectangular sedimentation basins.

Turbine generators in the 1,500–15,000-kw range are covered in a 35-page illustrated bulletin, No. 1960C-P, containing information on design, construction, operation, and testing. Copies may be obtained from Worthington Corp., Advertising & Sales Promotion Dept., Harrison, N.J.

Butterfly valves, 16–84 in., are described, with selection data, in Bul. 02 R 8287 (8 pages), issued by Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

Plastic pipe manufacturers whose products have been found satisfactory for potable water supplies are shown in a list published by National Sanitation Foundation Testing Lab., Inc., Ann Arbor, Mich.

General Filter Co., 925—2nd St., Ames, Iowa, offers a 4-page illustrated brochure (Bul. 5624) on "Multicell Filters" with "Multi-Plate" baffle underdrains, as well as 2-page bulletins on degasifiers (Bul. 5650), pressure aeration (Bull. 5651), and vertical flocculators (Bul. 5655), giving data and specifications.

Armco Pipe Saves City 21.7% on Industrial Water Line

The city of Cumberland, Maryland, built an 18-inch-diameter water pipe line some 26,500 feet long to supply water for a big new plant. When bids were opened, it was found that *Armco Welded Steel Pipe was 21.7% below* the lowest of three bids submitted on competitive pipe.

Most of the Armco Pipe was supplied in 50-foot sections. This meant fewer sections to haul and handle—fewer field joints. The contractor completed the job ahead of schedule.

For any water line you will find that Armco Steel Pipe offers many advantages. Diameters range from 6 to 36 inches; wall thicknesses from 9/64- to 1/2-inch. Coatings meet AWWA specifications; a spun enamel lining prevents tuberculation.

Write for complete data on Armco Pipe and Armco Gates for water works construction. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4057 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

This 50-foot length of Armco Steel Pipe is part of a 5-mile water line to an industrial plant at Cumberland, Maryland.

City Engineer: Charles R. Nuzum • **Consulting Engineer:** Robert T. Regester, Baltimore • **Special Design Engineer:** W. E. Piper

Contractor: The Cumberland Contracting Co.

ARMCO WELDED STEEL PIPE

ARMCO®

NEW MEMBERS

Applications received Jan. 1–31, 1957

Aaron, Bill, Chief Operator, Water Filtration Plant, 1916—26th St., Snyder, Tex. (Jan. '57) *P*

Alk, Lewis C., Mgr. of Tech. Service Dept., James B. Clow & Sons, Inc., 201–299 N. Talman Ave., Chicago, Ill. (Jan. '57) *MRPD*

Bagshaw, Grant H., Supt., St. Catharines Water Works Com., Municipal Bldg., St. Catharines, Ont. (Jan. '57)

Banthrum, Millard Nelson, Water Foreman, Water Dept., 100 N. Garfield Ave., Pasadena, Calif. (Jan. '57) *MD*

Baumer, William H., Special Asst. to Pres., Johnson & Johnson, 500 George St., New Brunswick, N.J. (Jan. '57) *R*

Beard, William George, Supt., Filtration Plant, Hagerstown, Md. (Jan. '57) *MPD*

Beebe, Frank D., Civ. Engr., Johns-Manville Sales Corp., 1530 Guildhall Bldg., Cleveland, Ohio (Jan. '57) *D*

Behn, Vaughn Crawford, Assoc. Prof. of Civ. Eng., Univ. of Delaware, Newark, Del. (Jan. '57) *RPD*

Belyea, Scott C., Supt. of Public Works, 60 W. Wattles Rd., Troy, Mich. (Jan. '57) *MD*

Bergin, Robert F., Power Engr., Pennsylvania Salt Mfg. Co., Wyandotte, Mich. (Jan. '57) *RP*

Bernhart, Alfred P., Prin. Engr., 19 Langden Ave., Toronto 9, Ont. (Jan. '57)

Berrey, Howard J., Dist. Sales Repr., Diamond Alkali Co., Union Commerce Bldg., Cleveland, Ohio (Jan. '57) *P*

Beveridge, Francis L., Supt., Dept. of Water & Sewers, Palm Ave., Hialeah, Fla. (Jan. '57) *MRPD*

Blaess, Jack L., Asst. City Engr., Pierre, S.D. (Jan. '57) *MPD*

Bowlen, Elmer T., Chemist, Water Dept., Billings, Mont. (Jan. '57) *P*

Brooks, Harry L., Pres. & Gen. Mgr., Brooks Products, Inc., 1125 Olney St., El Monte, Calif. (Jan. '57)

Brown, Joseph; *see* Farmersville County (Calif.) Water Dist.

Brundrett, Elmo Holley, Sales Engr., Johns-Manville Sales Corp., Box 255, Houston, Tex. (Jan. '57) *D*

Campbell, Wendell R., Accountant, Water Dept., 651—14th St., N.W., Atlanta, Ga. (Jan. '57) *M*

Case, Milton R., Member, Board of Trustees, 30 W. Main St., Webster, N.Y. (Jan. '57) *M*

Clifford, Robert Keaney, Asst. Engr., Louisville Water Co., 2611 Browns Lane, Louisville 5, Ky. (Jan. '57)

Collins, John H., Sales Repr., Thompson Pipe & Steel Co., 3001 Larimer St., Denver, Colo. (Jan. '57) *MD*

Crooks, Earl C., Director, Dept. of Water & Sewers, Hialeah, Fla. (Jan. '57) *MRPD*

Cross, Lewis B.; *see* Onondaga County (N.Y.) Water Authority

Dates, George C., Vice-Pres., Piersol-Pine Mfg. Co., Inc., Oaks, Pa. (Jan. '57) *MP*

Day, Robert V., Engr., Clyde E. Williams & Assocs., Inc., 312 W. Colfax Ave., South Bend, Ind. (Jan. '57) *P*

Dickerson, Robert Kendall, Civ. Engr., Leo A. Daly Co., 633 Insurance Bldg., Omaha, Neb. (Jan. '57) *MP*

Donovan, Eugene J., Graduate Student, Massachusetts Institute of Technology, Cambridge 39, Mass. (Jr. M. Jan. '57) *P*

Du Page County Health Dept., Orville L. Meyer, Dir. of Sanitation, 209 E. Liberty Dr., Wheaton, Ill. (Corp. M. Jan. '57) *MRPD*

Elliott, Carroll L., Supt., Water & Light Dept., 620—2nd St., South Virginia, Minn. (Jan. '57) *MD*

Elmore, Harold L., Public Health Engr., Tennessee Valley Authority, 725 Edney Bldg., Chattanooga, Tenn. (Jan. '57) *R*

Estes, Alfred C., Jr., Asst. Engr., Russ Mitchell, Inc., 5304 O St., Houston, Tex. (Jan. '57) *P*

Eure, John Anthony, 7833 Escanaba Ave., Chicago 49, Ill. (Jr. M. Jan. '57) *P*

Evans, Arthur I., Mgr., Public Utilities Com., 113 Front St., N., Campbellford, Ont. (Jan. '57) *MPD*

Farmersville County Water Dist., Joseph Brown, Mgr., Box D-6, Farmersville, Calif. (Corp. M. Jan. '57) *MD*

Fjeldsted, E. J.; *see* Weber Basin Water Conservancy Dist.

Follmer, John A., Draftsman, Water Div., 1640 S. Kingshighway, St. Louis, Mo. (Jan. '57) *MRD*

Fox, George Sidney, Ground Water Geologist, Leggette, Brashears & Graham, 551—5th Ave., New York 17, N.Y. (Jan. '57) *R*

Freeston, Robert C., Water Works & Sewage Instrumentation Engr., Industrial Div., Minneapolis-Honeywell Regulator Div., Wayne & Windrim Aves., Philadelphia 44, Pa. (Jan. '57) *P*

Fross, Craig A., Mfer.'s Repr., 3701 Norwood, Independence, Mo. (Jan. '57) *RPD*

Fryer, Colin J., Mgr., Hawaiian Branch, Dearborn Chem. Co., Box 2898, Honolulu 2, Hawaii (Jan. '57)

Funk, Stanton Curtis, Sales Engr., Waterworks Sales Co., 600 W. 48th Ave., Denver, Colo. (Jan. '57) *PD*

Gaither, C. Gordon, Partner, Howard K. Bell, 553 S. Limestone St., Lexington, Ky. (Jan. '57) *PD*

Gare, Leland R., Director of Public Works, Municipal Bldg., Birmingham, Mich. (Jan. '57) *M*

Gartmann, Hans, Chief Engr., Pump & Compressor Dept., De Laval Steam Turbine Co., Trenton 2, N.J. (Apr. '50)

Geismar, Edward V., Valuation Engr., American Water Works Service Co., 3 Penn Center, Philadelphia, Pa. (Jan. '57) *MP*

Goble, Harold G., Sales Engr., 600 W. 48th Ave., Denver, Colo. (Jan. '57) *RPD*

Gomella, Cyril, Mgr., Societe d'Etudes pour le Traitement et l'Utilisation des Eaux, 5, rue Berthezene, Algiers, Algeria (Jan. '57) *RPD*

Grear, Ronald Blaine, Civ. Engr., Leo A. Daly Co., 633 Insurance Bldg., Omaha, Neb. (Jan. '57) *RD*

Greenley, Don Harrison, Supt. of Distr., Water Dept., City Hall, Billings, Mont. (Jan. '57) *D*

Gunther, Frank A., Sales Supervisor, Water Treatment Chemicals, American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y. (Jan. '57) *RP*

Halle, Lee Jay, Operating Engr., Williams Air Force Base, Ariz. (Jan. '57) *PD*

Hanson, Robert J., Sales Engr., Dresser Mfg. Div., Dresser Industries, Inc., Bradford, Pa. (Jan. '57)

Harbaugh, Robert R., Chief Engr., Water & Elec. Distr., 127 E. 3rd St., Muscatine, Iowa (Jan. '57)

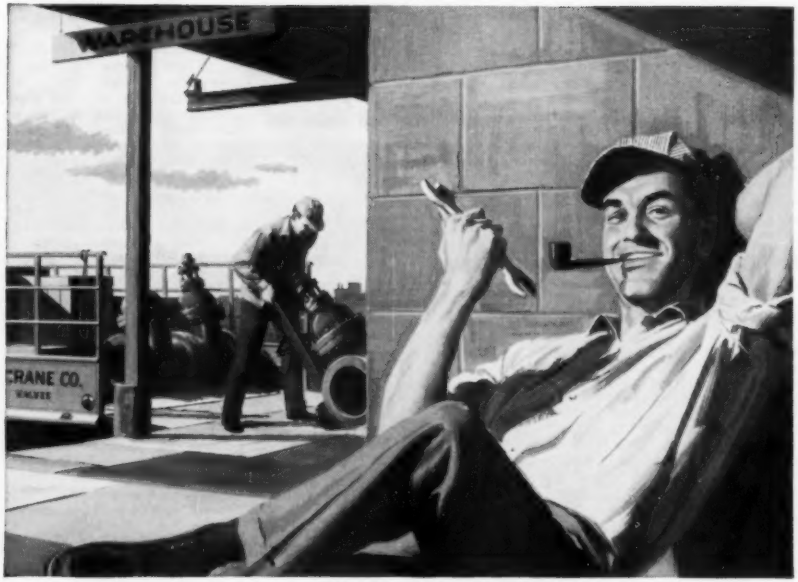
Harper, Kenneth E., Mgr., Culligan Soft Water Service, 195—4th St., San Bernardino, Calif. (Jan. '57)

Hatley, Herbert W., Chem. Salesman, Chemical Services, Inc., 1160 Zonolite Rd., N.E., Atlanta, Ga. (Jan. '57) *P*

Heater, Collier A., Meter Reader, Box 721, Dumas, Tex. (Jan. '57)

Hert, Oral H., San. Engr., State Board of Health, 1330 W. Michigan St., Indianapolis, Ind. (Jan. '57) *R*

(Continued on page 100 P&R)



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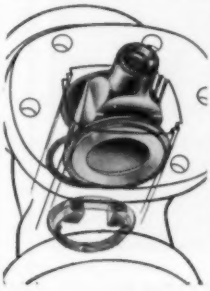
Everywhere these new Crane AWWA Valves have been installed, maintenance costs have dropped. Here are reasons why:

The design of the Crane 4-piece disc assembly and guide ribs permits the trunnion-mounted twin discs to rotate freely as they are raised or lowered. Concentrated wear on both seats and discs is prevented. The simplified wedging action assures positive seating . . . tight closing. And the guide ribs prevent the disc assembly from jamming or disengaging.

Crane AWWA Valves meet all AWWA specifications. You also get the Crane 2-piece gland and gland flange with ball-type bearing Prevents binding on stem under uneven pull-up on gland bolts.

These valves are available with hub, flanged or mechanical joint ends —in sizes 2″ to 12″. For specification data, call your local Crane Representative, or write to address below.



View of disc assembly showing its simplicity. Assembly is suspended from stem, which engages upper spreader. Discs are suspended from upper spreader on trunnions. Disc flange guides hold assembly between guide ribs.

CRANE VALVES & FITTINGS

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Since 1855—Crane Co., General Offices: Chicago 5. Branches and Wholesalers in All Areas

(Continued from page 98 P&R)

Hetrick, Scott R., Supt., Water & Sewage Treatment Plants, Board of Public Affairs, Huron, Ohio (Jan. '57) *P*

Hilton, G. O., Cons. Engr., 5302 Kensington, Wichita, Kan. (Jan. '57)

Hoag, Lyle N., Jr., Engr., Brown & Caldwell, 66 Mint St., San Francisco, Calif. (Jan. '57) *D*

Holland, Willard Raymond, Supt. of Utilities, Light & Water Plant, Madisonville, Ky. (Jan. '57) *MPD*

Jacobson, George L., Assoc. Prof. of San. Eng., School of Mines & Technology, Rapid City, S.D. (Jan. '57)

King, Maurice A., Asst. Mgr., Water Works, 1003 Locust St., Des Moines 7, Iowa (Jan. '57) *M*

Klopp, Ralph M., Repr., Johns-Manville Sales Corp., 1530 Guildhall Bldg., Cleveland 15, Ohio (Jan. '57) *D*

Kmiecik, Sub S., Engr., Tech. Service Dept., James B. Clow & Sons, Inc., 201–299 N. Talman Ave., Chicago, Ill. (Jan. '57) *MRPD*

Knox, J. A. J., Design Engr., Canadian British Eng. Consultants, 1662 Ave. B, Toronto 12, Ont. (Jan. '57)

Krause, William G., Sales Engr., Worthington Corp., 400 W. Madison, Chicago, Ill. (Jan. '57) *D*

LaRose, Maurice J., City Engr., Thetford Mines, Que. (Jan. '57) *MRPD*

Lee, George June, Director of Public Works, 1916—26th St., Snyder, Tex. (Jan. '57) *M*

Lloyd, R. D. C., Engr., J. F. MacLaren Assocs., Confederation Life Bldg., Bloor St., E., Toronto, Ont. (Jan. '57)

Lowe, William R., Water Plant Supt., Guthrie, Okla. (Jan. '57) *RP*

Margrave, G. E., San. Engr., Div. of San. Eng., State Dept. of Public Health, 616 State Office Bldg., Springfield, Ill. (Jan. '57) *RPD*

Mattson, Walfrid T., Chemist & Sanitarian, Public Utilities Com., Hibbing, Minn. (Jan. '57) *PD*

McGovern, John J., Acme Valve Installing Co., 279 Seaman St., New Brunswick, N.J. (Jan. '57)

McNeary, Francis, Water & Sewer Comr., City Hall, Aberdeen, S.D. (Jan. '57) *MRPD*

Menzenhauer, Fred C., 554 Seminole St., Oradell, N.J. (Apr. '54)

Meyer, Fred L., Salesman, Honolulu Iron Works Co., Box 3140, Honolulu, Hawaii (Jan. '57) *M*

Meyer, Orville L.; *see* Du Page County (Ill.) Health Dept.

Middleton, Howard, Member, Board of Trustees, 30 W. Main St., Webster, N.Y. (Jan. '57) *M*

Mitchell, Ansel N., 310 Ward Pkwy., Kansas City 12, Mo. (Jan. '57)

Model Irrigation Dist. No. 18, Ivan J. Wheldon, Water Supt., 1400 S. Pierce Rd., Opportunity, Wash. (Munic. Sv. Sub. Jan. '57) *MPD*

Moses, Phillip, Design Engr., Clyde E. Williams & Assocs., Inc., 312 W. Colfax Ave., South Bend, Ind. (Jan. '47) *MRPD*

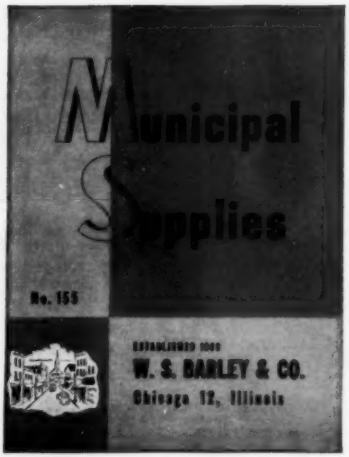
Nadler, Harold O., Vice-Pres., H. E. Humphrey, Alley & Richards, Inc., 370 Lexington Ave., New York 17, N.Y. (Jan. '57) *MRPD*

Nevins, John, Chief Draftsman, Water Div., Distr. Sec., 1640 S. Kingshighway, St. Louis, Mo. (Jan. '57) *MD*

Newman, Warner J., 2 Virginia Ave., Pompton Plains, N.J. (Jan. '57)

Niznan, Rudolph J., Dist. Repr., The Permutit Co., 10 Wilsey Square, Ridgewood, N.J. (Jan. '57) *P*

(Continued on page 102 P&R)



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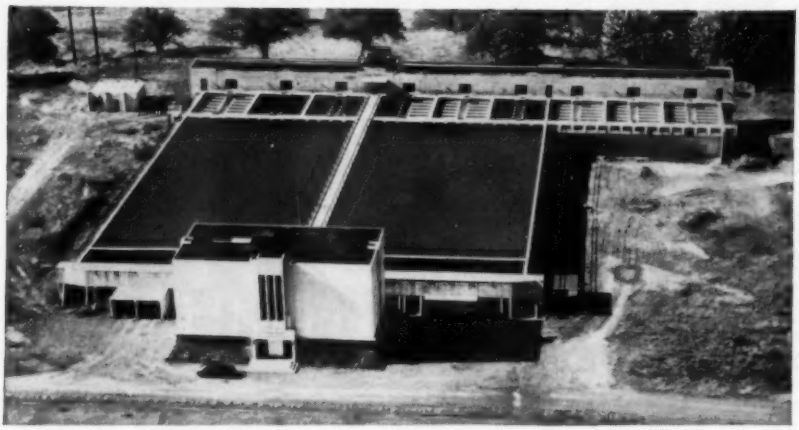

Ramuc® Mildew-Resistant Enamel guards 250-foot-long tunnel connecting headhouse with pumping section. Flanked on either side by one million gallons of cold water in twin reservoirs, the warmer tunnel is subject to heavy condensation and dripping. Tunnel is but one of many Inertol-protected areas of this plant.

Pacific Northwest's Largest Municipal Water Plant

The largest municipal water filtration plant in the Pacific Northwest, the 37.5-MGD Hayden Bridge installation serves over 60,000 persons in the fast-growing Eugene metropolitan area.

Inertol coatings, specified for this plant by Consulting Engineers Stevens & Thompson, Portland, provide attractive, cost-cutting protection . . . safeguard surfaces against condensation, mildew, abrasion, submersion and weather.

Specifications for Ramuc Mildew-Resistant Enamel

A glossy, mildew-resistant, chlorinated natural rubber-base coating, in color, for non-submerged concrete, steel and indoor wood surfaces.

Concrete Surfaces: *Colors:* color chart 560. *No. of coats:* one coat *Ramuc* Mildew-Resistant Enamel over two coats *Ramuc* Undercoater. For flat finish, two coats *Ramuc* Mildew-Resistant Flat to bare masonry—omit undercoater. *Coverage:* 250 sq. ft. per gal. per coat. *Approximate mil thickness per coat:* 1.2. *Drying Time:* 24 hours. *Primer: Ramuc* Mildew-Resistant Undercoater (2 coats). *Thinners: Inertol* Thinner 2000-A for brushing; 2000 for spraying. *Application:* Brushing: *Ramuc* Mildew-Resistant Enamel—brush type, as furnished. Spraying: *Ramuc* Mildew-Resistant Enamel—spray type, add sufficient Thinner 2000 for proper atomization.

Buy Inertol paints direct from the manufacturer. Shipment within three days from our plant, or from nearby warehouse stocks. Write today for free "Principal Types of Protective Coatings," a short course in practical paint technology.

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Inertol

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See us at the American Water Works Association Convention—Booth 405

(Continued from page 100 P&R)

O'Hara, John Keith D., Exec. Engr., Water Supply Branch, Public Works Dept., Half Way Tree P.O., Jamaica, B.W.I. (Jan. '57) *P*

Olson, Kenneth Frederick, Civ. Engr., Water Div., Dept. of Public Utilities, Tacoma, Wash. (Jan. '57) *D*

Onondaga County Water Authority, Lewis B. Cross, Deputy Gen. Mgr., Box 1004, Syracuse 1, N.Y. (Corp. M. Jan. '57) *M*

Owen, Clarence; *see* Seaside (Ore.) Water Dept.

Page, Morgan C., Mgr., Grover City Cons. Water Dist., Box 407, Grover City, Calif. (Jan. '57) *MRPD*

Park, Scott C., Mgr. Manatee County Water Co., Holmes Beach, 83rd St., Fla. (Jan. '57)

Perron, Charles H., Design Engr., Frederick Ferriss, 5 Carden Hill, Morristown, N.J. (Jan. '57) *RPD*

Pershe, Edward Richard, Civ. Engr., Black & Veatch, 1500 Meadow Lake Pkwy., Kansas City, Mo. (Jan. '57) *RPD*

Ploss, Richard S., Research Chemist, International Salt Co., Inc., 254 W. 31st St., New York 1, N.Y. (Jan. '57) *PD*

Price, James Robert, Jim Price & Co., 7990 M-15, Clarkston, Mich. (Jan. '57) *M*

Proctor, George Nelson, Vice-Pres., The Permutit Co., Old Philadelphia Pike, Lancaster, Pa. (Jan. '57) *RP*

Reid, David S., Sanitarian, International Cooperation Administration, USOM/Iran, APO 205, New York, N.Y. (Jan. '57) *PD*

Reinhard, Carl A., Sales Engr., Johns-Manville, 816 W. 5th St., Los Angeles 17, Calif. (Oct. '56) *MRD*

Robertson, John J., Gen. Engr., Water Works Design Branch, US Corps of Engrs., 1st & Douglas St., N.W., Washington, D.C. (Jan. '57) *MP*

Robertson, Reed Stuart, Group Leader, National Aluminate Corp., 6216 W. 66th Pl., Chicago 38, Ill. (Jan. '57) *MP*

Roemer, George W., Supt., Elizabeth Township Authority, Buena Vista, Pa. (Jan. '57) *M*

Rogers, Joseph C., Clement J. Gaffney Water Meter Repairs, 363 Flushing Ave., Brooklyn 5, N.Y. (Jan. '57) *D*

Rogers, Sherman L., Distr. Engr., Metropolitan Dist. Water Bureau, 115 Broad St., Hartford, Conn. (Jan. '57) *MD*

Royle, Albert A., Sr. Civ. Engr., L. H. Schwindt & Co., Ltd., Box 404, Burlington, Ont. (Jan. '57)

Saville, George William, Jr., Lab. Technician, Div. of Water & Sewers, 815 E. Jefferson, Phoenix, Ariz. (Jan. '57) *P*

Schaumburg, George J., Cons. Engr., 2678 Laurel Ave., Beaumont, Tex. (Jan. '57) *RPD*

Schmidt, Eugene A., City Engr., 408 City Hall, Milwaukee, Wis. (Jan. '57) *MPD*

Schutz, Herbert N., Supervisor of Constr. & Maint., Gary-Hobart Water Corp., 650 Madison St., Gary, Ind. (Jan. '57) *D*

Seaside Water Dept., Clarence Owen, Supt., Seaside, Ore. (Corp. M. Jan. '57) *MPD*

Sellers, Miller T., Secy., Water Works Board, Evergreen, Ala. (Jan. '57) *M*

Shannon, Bill W., Asst. Engr., Russ Mitchell, Inc., Box 8068, Houston 4, Tex. (Jan. '57) *P*

Sizemore, Roy, Supt. of Public Works, Hazard, Ky. (Jan. '57) *MP*

Smith, Herman H., Supt., Dept. of Water Works, La Grange, Ind. (Jan. '57) *MPD*

Solberg, Bjarne, Chief Operator, Water Dept., Billings, Mont. (Jan. '57) *P*

Speer, Ralph E., Jr., Staff Engr., State Municipal League, 205 S. State, Ann Arbor, Mich. (Jan. '57) *MPD*

Stanford, Brooke L., Underground Piping & Irrigation System Contractor, A & B Lawn Irrigation Co., 20429 Ardmore, Detroit 35, Mich. (Oct. '56) *RPD*

Starr, Dana Benton, Chief Engr., Industrial Pump Corp., Box 5116, Tampa, Fla. (Jan. '57) *RPD*

Stemp, Chester L., Cons. Engr., Chester L. Stemp & Assocs., 132 N. Calumet Rd., Chesterton, Ind. (Oct. '56) *MRPD*

Stevenson, Jack A., Salesman, Lebanon Chem. Co., 185 Pinelynn Rd., Glen Rock, N.J. (Jan. '57) *P*

Steventon, Robert W., Engr. of Water System, Dept. of Water Supply, 735 Randolph St., Detroit 26, Mich. (Oct. '56) *MD*

Steward, Robert, Foreman, Water Dept., Municipal Utilities, Lowell, Mich. (Oct. '56) *RPD*

Stovall, James Hunt, Project Engr., Concrete Sec., International Paper Co., Pine Bluff, Ark. (Oct. '56) *RP*

Strader, Melvin C., Sewer & Water Engr., Johnson & Anderson, Inc., 1307 Pontiac State Bank, Pontiac, Mich. (Jan. '57) *MRPD*

Street, William H., Plant Mgr., Jones Chemicals, Inc., 2365 Dennis St., Jacksonville, Fla. (Jan. '57) *P*

Stuhlfauth, Robert G., Salesman, Eddy Valve Co., 140 Cedar St., New York 6, N.Y. (Jan. '57) *D*

Susag, Russell H., Student-Teaching Asst., San. Eng. Dept., Univ. of Minnesota, 1227 S.E. 44th St., Minneapolis, Minn. (Jan. '57)

Swarr, John H., Supervisor, Day & Zimmerman, Inc., 1700 Sansom St., Philadelphia, Pa. (Oct. '56) *M*

Sweetman, Jack Murray, Civ. Eng. Assoc., Dept. of Water & Power, 207 S. Broadway, Los Angeles 12, Calif. (Jan. '57) *M*

Talley, Charles A., Supt. of Sewer & Water & Filter Plant Operators, E. College, Fayetteville, Tenn. (Oct. '56) *P*

Trice, John Q., Asst. Mgr., Research Pipe Dept., Johns-Manville Research Center, Manville, N.J. (Jan. '57) *D*

Trimble, Robert A., Secy.-Supt., San Luis Rey Heights Mutual Water Co., Star Rte., Bonsall, Calif. (Jan. '57) *MRPD*

Van Stralen, R. Franklynn, Pres., Chansall Mutual Water Co., 6633 Chanslor Ave., Bell, Calif. (Jan. '57) *M*

Vezina, Maurice G., Student, Graduate House, Massachusetts Institute of Technology, Cambridge, Mass. (Jan. '57) *P*

Wacker, Frank A., Mgr. of Utilities, Plymouth, Wis. (Jan. '57) *M*

Walsh, Edward S., Mfer.'s Repr., 246 S. 1st St., San Jose, Calif. (Jan. '57) *PD*

Warren, Edgar G., Regional Sales Mgr., Pennsylvania Salt Mfg. Co., 2328 Buhl Bldg., Detroit, Mich. (Jan. '57)

Watson, Allan D., Plant Chemist, Brunner Mond Canada, Ltd., Amherstburg, Ont. (Jan. '57) *P*

Waugh, Harvey C., Roberts Filter Mfg. Co., 6th St. & Columbia Ave., Darby, Pa. (Jan. '55)

Weaver, Ralph E., Sales Engr., Johns-Manville Sales Corp., 1500 W. 3rd Ave., Columbus 12, Ohio (Jan. '57) *D*

Weber Basin Water Conservancy Dist., E. J. Fieldsted, Mgr.-Secy., 506 Kiesel Bldg., Ogden, Utah (Corp. M. Jan. '57) *MRPD*

Weiss, Harold, Dist. Sales Mgr., Sparling Meter Co., 85 Industrial St., San Francisco 24, Calif. (Jan. '57) *D*

Wesson, George A., Jr., Development Engr., Dorr-Oliver Inc., Barry Pl., Stamford, Conn. (Jan. '57) *P*

Wetzel, Vernon D., San. Officer, Board of Health, 337 E. Wayne St., Fort Wayne, Ind. (Jan. '57)

Wheldon, Ivan J.; *see* Model Irrigation Dist. No. 18 (Wash.)

Williams, Max E., Constr. Foreman, Water Co., 117 Northwestern Ave., West Lafayette, Ind. (Oct. '56)

Wilson, Harry, Supt. of Water Works, Chester, W.Va. (Jan. '57) *M*

Wood, Frank Osborne, Tech. Service Repr., Diamond Alkali Co., Research Center, Box 348, Painesville, Ohio (Jan. '57) *P*

Woodcock, John G., Design Engr., M. H. Dineen & Assoc., Ltd., 168 Charlotte St., Ottawa, Ont. (Jan. '57)

Woodley, Louis G., Supt. of Utilities, Water & Sewage Treatment Plant, Lafayette, Ind. (Jan. '57) *MD*

Yatabe, M., Gore & Storrie, Ltd., 1130 Bay St., Toronto, Ont. (Jan. '57)

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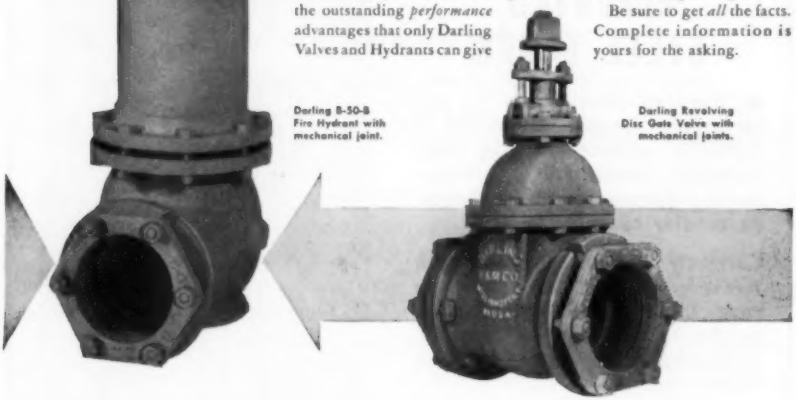

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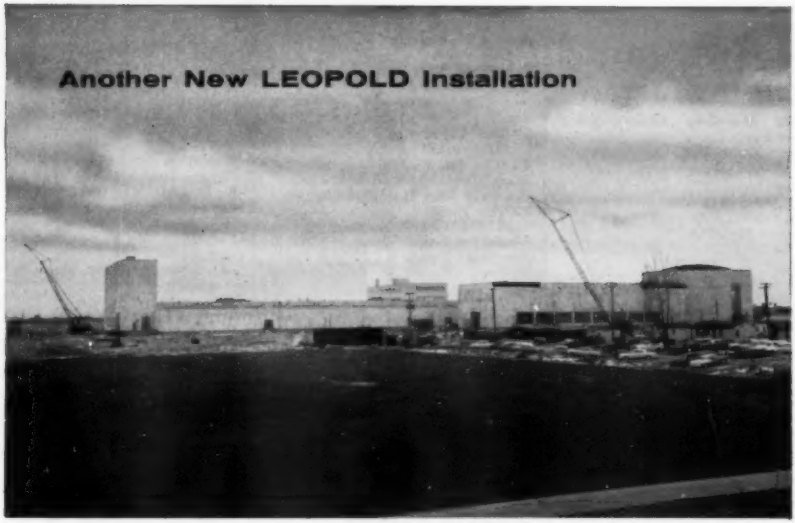

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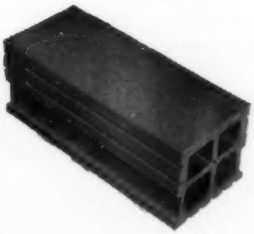

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Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Infilco Inc.
Minneapolis-Honeywell Regulator Co.
Simplex Valve & Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.
Sparling Meter Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
General Filter Co.
Graver Water Conditioning Co.
Permutit Co.

Sodium Aluminate:
Monolith Portland Midwest Co.

Sodium Chloride:
Frontier Chemical Co.

Sodium Fluoride
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon, Inc.

Sodium Hypochlorite:
John Wiley Jones Co.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride
American Agricultural Chemical Co.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Cochrane Corp .
General Filter Co.
Infilco Inc.
Morton Salt Co.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
Mueller Co.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons

Roberts Filter *means...*

MUNICIPAL WATER PURIFICATION

The combined capacity of Roberts-equipped filtration plants is well over 5 billion gallons (5,000,000,000) per day. Regardless of the size of the plant or the nature of the filtration problem, Roberts Filter can be depended upon for equipment that is reliable in years of service.

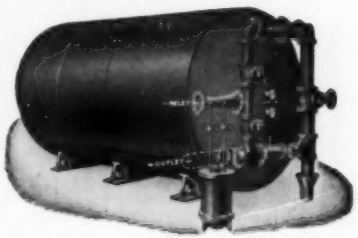
INDUSTRIAL WATER RECTIFICATION

Water treatment has long been a specialty of Roberts Filter. Zeolite water softeners are guaranteed to meet all requirements for which recommended, and are available in a wide range of capacities. Roberts water conditioning equipment is widely used to control precisely the desired chemical content of water for industrial use.

SWIMMING POOL RECIRCULATING SYSTEMS

The combination of thoroughly clarified water and efficient recirculation are features for which Roberts pools are famous. Systems for both outdoor and indoor pools are designed and installed by men long experienced in the conditions peculiar to a successful swimming pool installation.

PRESSURE FILTERS



Closed pressure filters have wide usage where gravity filters are not justified. Roberts vertical filters are available in standard types from 12" to 96" diameter; horizontal pressure filters are all 8'0" in diameter and in varying lengths from 10'0" to 25'0".

When you think of good water—think of Roberts Filter

MECHANICAL EQUIPMENT BY ROBERTS FILTER MFG. CO.

Roberts Filter

Manufacturing Company • Darby, Penna.

M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Water Conditioning Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tenoning Tools:
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.

Water Softening Plants: see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.

neither RAIN, SNOW nor TRENCH CONDITIONS stop this pipeline!

They're laying K&M Pressure Pipe. It's made of Asbestos-Cement. It's light in weight, no heavy machinery is needed to handle it. It's strong . . . uneven ground pressure is not a hazard. And it's quickly assembled, even by unskilled labor, with K&M's EXCLUSIVE "Fluid-Tite"® Coupling.

But best of All . . . first cost is last cost! K&M Asbestos-Cement Pressure Pipe is non-metallic . . . it's made of practically indestructible ingredients . . . mineral asbestos fibers, with the tensile strength of fine steel, and age-hardening portland cement . . .

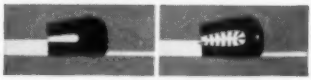
It's non-corroding, non-electrolytic, non-tuberculating. Its smooth steel-mandrel-shaped interior walls reduce friction to a minimum, and they stay that way! Pumping costs start low . . . stay low.

Write for complete literature.

6" water system for new housing development being laid by Keystone Tank and Trench Company, Mt. Holly, N. J., for the Yardley Water & Power Company, Yardley, Pa. Allen Brumbaugh, Superintendent of the utility, said, "After this installation I am sold on the K&M 'Fluid-Tite' Coupling and K&M Asbestos-Cement Pipe."

The Exclusive K&M Fluid-Tite Coupling!

The holes in the rings are the secret!



A B

A Compressed ring allows easy, quick pipe assembly.

B Internal water pressure expands rings . . . higher pressure, tighter seal.

K&M Best in asbestos® **KEASBEY & MATTISON** COMPANY • AMBLER • PENNSYLVANIA

Rockwell Dual Unit Compound Meter Assemblies

EASIEST To Handle, Install, Service

Big, bulky 8 in. compound meters are always a trial to install, even more of a problem to service. Now, with Rockwell—two meter single register compound manifolds you can save time and money. The complete assembly weighs approximately 100 lbs. less than a single big meter. Two men can handle it with ease. Maintenance of this Rockwell unit is a cinch. Either meter can be used to record off-peak loads while a new or repaired meter is being installed. And remember, Rockwell Dual Unit meter assemblies are razor sharp in the measurement department. They record *all the flows* with far greater accuracy than a single 8" compound. And they cost less. Write for latest bulletin.

ROCKWELL MANUFACTURING COMPANY
PITTSBURGH 8, PA. Atlanta Boston Charlotte Chicago Dallas Denver Houston Los Angeles Midland, Tex. New Orleans New York N. Kansas City Philadelphia Pittsburgh San Francisco Seattle Shreveport Tulsa In Canada: Rockwell Manufacturing Company of Canada, Ltd., Toronto, Ontario

ROCKWELL WATER METERS

A Size and Type For Every Kind of Service

Water Treatment, too, needs
INDIVIDUAL DIAGNOSIS

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.

"Plantation Gardens" Florida

DORRCO ALDRICH PeriFilter* System

Meets Filtration Requirements of 1000 Home Subdivision

Consulting Engineers: Philpott, Ross & Saarinen, Ft. Lauderdale, Florida
Owner-Builder: Utilities Construction Company, Ft. Lauderdale, Florida

Plantation Gardens, an exclusive subdivision of 1000 homes having a population of 3500 persons, recently started up this compact water treatment plant for softening and color removal.

A Dorrco Aldrich PeriFilter System, consisting of a Dorrco Hydro-Treator surrounded by an annular rapid sand filter, was selected as the most economical answer to meet the conditions. The plant is designed to handle an average flow of 0.53 MGD with plans for enlargement at a future date.

Advantages of the PeriFilter system include lower construction costs because both pre-treatment unit and filter are installed in the same tank. Valves and piping are greatly simplified. Reduced head losses and simple operation add up to lower operating costs.

If you'd like more information on the PeriFilter System write for Bulletin No. 9042. No obligation, of course.

Hydro-Treator, PeriFilter T.M. Reg. U. S. Pat. Off.

Every day, nearly 8½ billion gallons of water are treated with Dorr-Oliver equipment.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

LEADITE

Trade Mark Registered U. S. Pat. Office

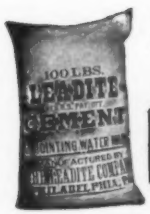
Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%



THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking